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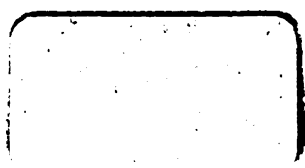
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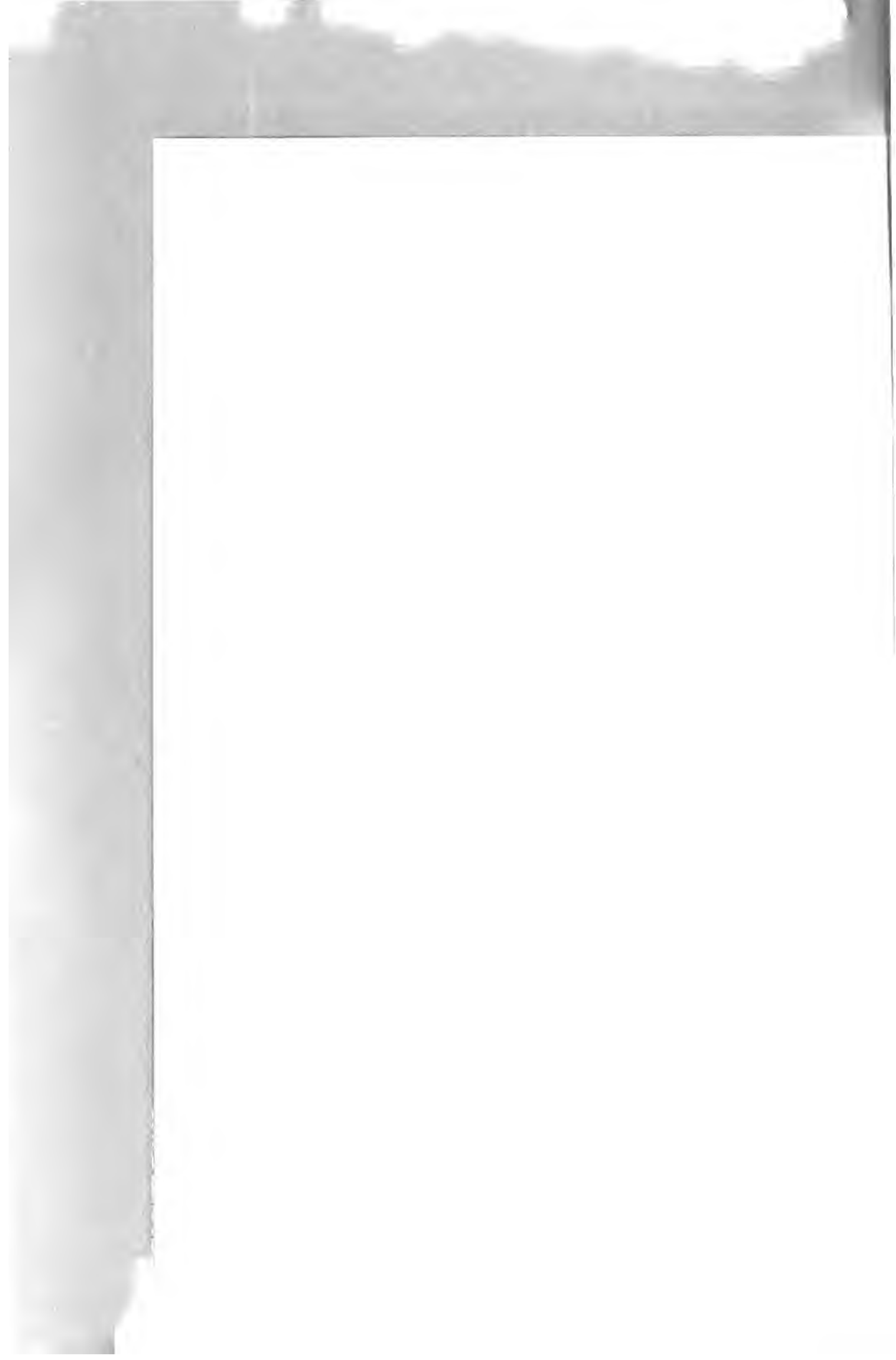
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HERDMAN MITCHELL CLELAND



1870
1871

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DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

X
A STUDY

OF THE

FAUNA OF THE HAMILTON FORMATION
OF THE CAYUGA LAKE SECTION
IN CENTRAL NEW YORK.

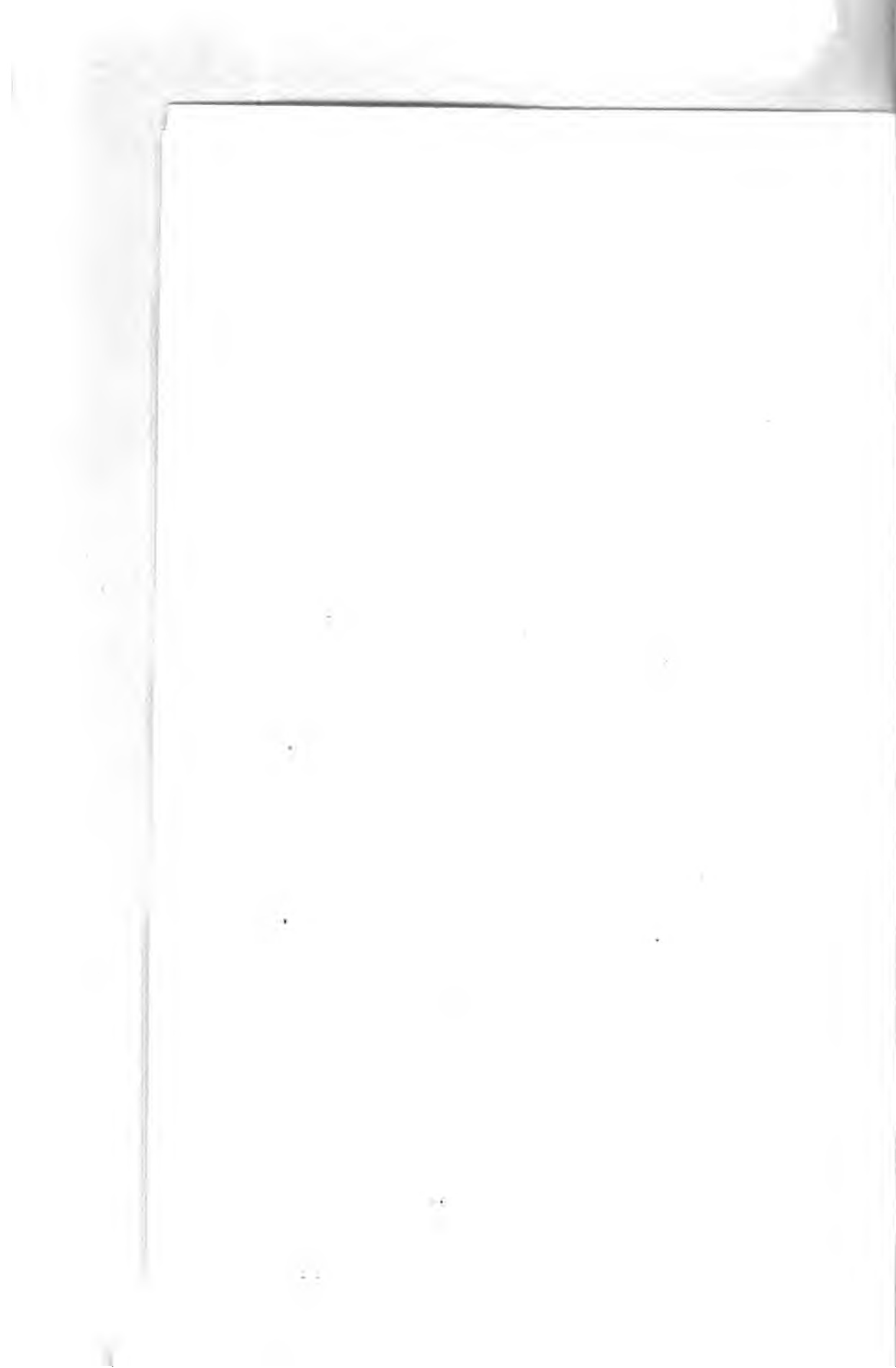
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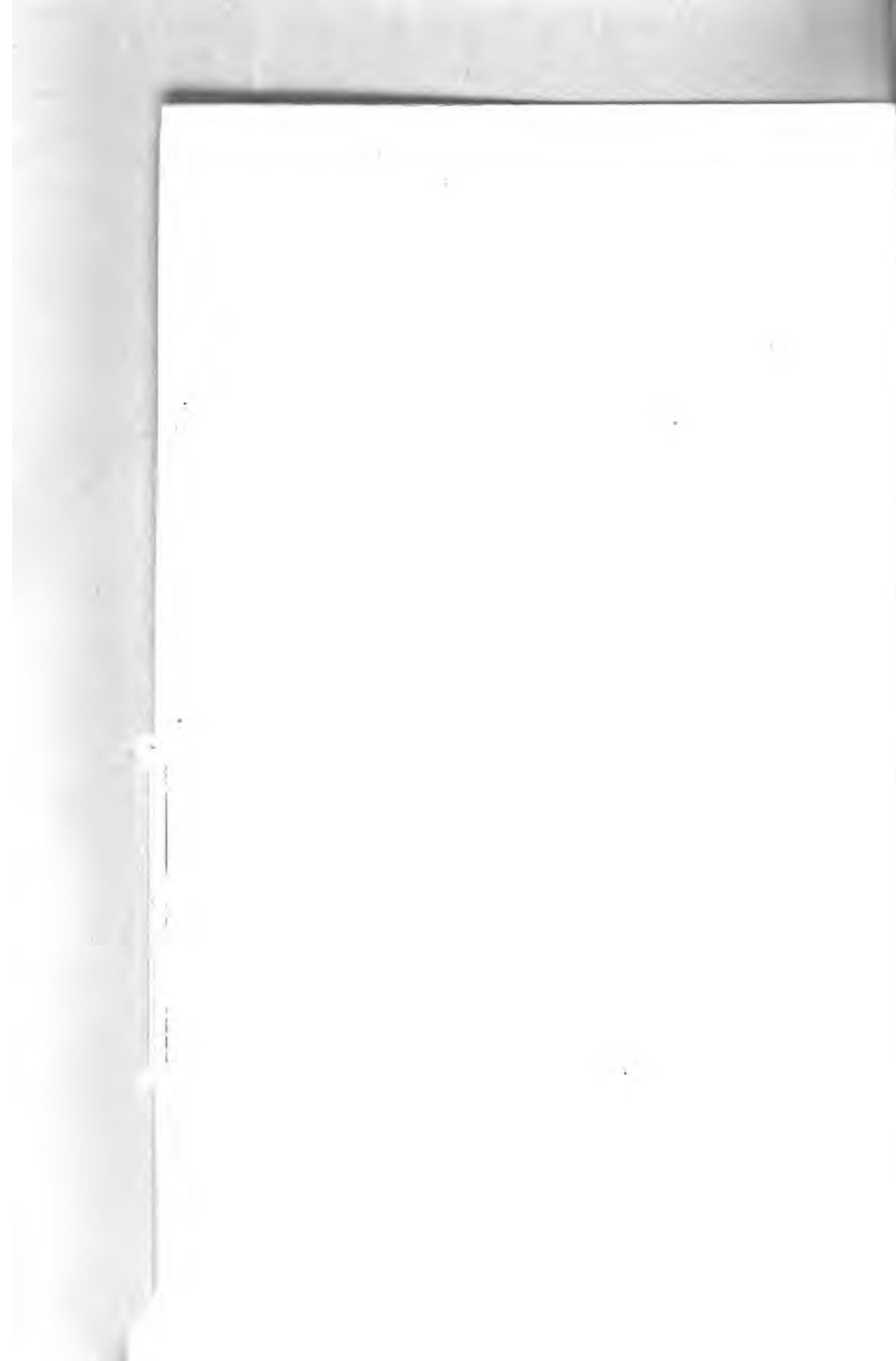
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1917
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H. S. Cleland

LETTER OF TRANSMITTAL.

YALE UNIVERSITY,
New Haven, Conn., June 23, 1902.

SIR: I have the honor to transmit herewith, for publication as a bulletin of the United States Geological Survey, the manuscript of a paper entitled A Study of the Fauna of the Hamilton Formation of the Cayuga Lake Section in Central New York, prepared at my suggestion by Herdman Fitzgerald Cleland.

Respectfully, yours,

HENRY SHALER WILLIAMS,
Geologist and Paleontologist.

HON. CHARLES D. WALCOTT,
Director of United States Geological Survey.



1911
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INTRODUCTION.

By HENRY SHALER WILLIAMS.

The following paper is a contribution to the knowledge of the fossil faunas of the Devonian of the United States. It was begun by Mr. Cleland as a piece of research work in the course of study for the doctorate degree at Yale University, and was used as a thesis in taking the degree of doctor of philosophy in June, 1900. During the summer of 1901 some additional work was put on it, based upon more extended field work.

The value of the investigation consists chiefly in the statistics it furnishes as to the approximate composition of each of the successive faunules making up the total fauna occupying the Hamilton formation of central New York. In it account is given of the species obtained in a careful and full examination of every foot of the section from the top of the Onondaga (Corniferous) limestone to the base of the Tully limestone, both of which are well marked in the Cayuga Lake section, thus constituting definite limits for the Hamilton formation of this particular region.

All the fossiliferous zones (seventy-six in number) were examined, and upon analysis of the faunules of each zone those which were so closely alike as to signify practically the same set of species, associated in the same biological equilibrium of relative abundance, were grouped together, constituting in all twenty-five separate faunules. These may properly be described as the faunules of the twenty-five successive hemeræ into which the Hamilton epoch of this section may be distinguished by its fossils. These faunules are associated with more or less definite changes in the character of the sediments in which they were buried. The separate divisions of the formation thus recognized by slight differences in faunal composition as well as in lithologic constitution may be called zones. The Hamilton formation, its fauna, and the particular section here studied are well known to paleontologists, so that the species can be easily recognized and listed. In making the collections special attention was given to the discovery of the relative abundance of the species found associated together in each rock stratum. Direction was given to collect the fossils as near as possible in the proportion of numbers presented by the natural occurrence in the rocks. Instead of attempting to dis-

cover rare species, the purpose was to let the preserved collection represent as perfectly as possible the natural proportion of association. The working up of the collection was made to express this natural proportion expressed by the species.

The identification of species is probably always affected more or less by personal judgment. In order to make the statistics of the greatest relative value, therefore, no attempt was made to criticise these personal elements in the author; and while it is probable that another worker dealing with the same specimens would not reach absolutely identical listing of species, it is probable that the errors, if any, from inaccuracy of specific identification are so small relatively as to not disturb the statistical value of the facts recorded. Further and more exhaustive search, also, may be expected to considerably modify the statistics here given; but even this fact does not detract from the value of those here recorded. The more refined the analyses become the more perfect will be our knowledge of faunal compositions. The present investigation is a step in the direction of attaining the fullest possible perfection in recording faunal statistics, and in making these faunal analyses as perfect as they can be made, toward which end the contributions of many workers will be needed. With such statistics in hand we may hope to understand better the laws of evolution as affected by and related to the varying conditions of environment and time.

It will be noticed that the thickness of the Hamilton, as measured by Prosser in the Ithaca well, is 1,224 feet—that is, between the top of the Onondaga (Corniferous) limestone and the base of the Tully limestone. The exact thickness was not determined by the author. The reason for this is that the great thickness and similarity in the character of the rock of Zones B and C made the accurate measurement of these zones impossible. This is shown in the section (fig. 2) by broken lines. Nevertheless it is believed that the discrepancy does not affect the accuracy of the succession of the fossiliferous zones recorded in this paper. Attention is here called to the fact in order to show how difficult it is to make exact correlation for short distances when the sediments are of similar composition and structure and the general fauna is the same. For the purpose of ascertaining the exact thickness of each zone, a continuous section is necessary, but a long series of shorter sections, where the dip is slight, offers the advantage of a greater number of exposures of the rocks for the collection of the fossils. It is hoped that the present sample of what can be done in the way of an historical study of a fossil fauna may inspire other workers to make similar studies of the rocks in their own localities for comparison and demonstration of the geographical as well as the geological modifications of fossil faunas.

Hamilton 1899 *1901* *Compliments of*
Wm. B. Peck

PREFACE.

The material for this study was collected during three months of the summer of 1899 and during May, 1901, from the Hamilton formation exposed along the east side of Lake Cayuga and the west side of Seneca Lake. Commencing at the Onondaga (Corniferous) limestone, an attempt was made to collect the complete faunule from each zone throughout the entire Hamilton formation up to the Tully limestone.

In the identification of the fossils the principle has been followed that unless absolutely necessary no new species or varieties should be described, but that all doubtful specimens should be referred to species already figured.

The writer is indebted to Prof. H. S. Williams for many helpful suggestions concerning methods of work.



Cleland, R. F. 1711 *Compliments of R. Cleland*

A STUDY OF THE FAUNA OF THE HAMILTON FORMATION OF THE CAYUGA LAKE SECTION IN CENTRAL NEW YORK.

By HERDMAN FITZGERALD CLELAND.

CHAPTER I.

GENERAL DESCRIPTION AND GENERAL GEOLOGY OF CAYUGA LAKE REGION.

GENERAL DESCRIPTION.

The region studied is about 70 miles west of the center of New York State, and extends across about one-third of the State from north to south, the center of the region being nearly in the center of the north-south line. Cayuga Lake, along the east side of which the material for this study was collected, is one of the so-called "finger lakes" of the State, and, with its outlet, forms the boundary between Seneca and Cayuga counties.

In the western two-thirds of the State the strata strike in an east-west direction and dip to the south. Because of this southerly dip it is possible for one to see a large part of the Paleozoic section in a comparatively short distance in passing from north to south. The Cayuga Lake region itself embraces all of the formations between and including the Salina and the Ithaca.

This region is overlain by glacial drift, which hides the rock, except where worn away by erosion. Almost every stream that enters the lake has cut a deep gorge through the drift and into the shale, making excellent exposures. The gorges thus formed often have banks of shale 100 feet or more in height. In all of these creeks there are from one to four falls, the highest of which are caused by four strata of limestone and the hard sandstones or flags of the Portage. A description of Shurger Glen, about 5 miles from the south end of the lake, will, in a general way, answer for all the streams flowing into the lake, the only difference being that the streams farther down the lake do not flow over the Tully limestone, Portage sandstone, etc.,

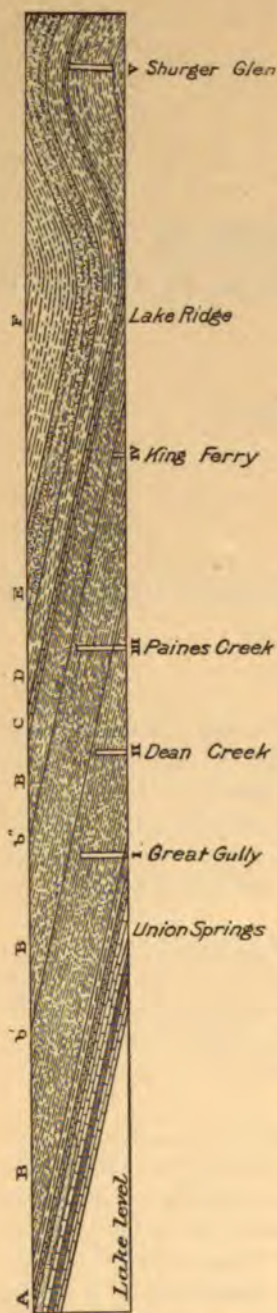


FIG. 1.—Cayuga Lake section.
A, Marcellus shale; B, Hamilton formation; b', limestone of zone D; b'', Encrinal beds; C, Tully limestone; D, Genesee shale; E, Portage; F, Ithaca.

and consequently have fewer falls. In Shurger Glen there are four sets of falls. The first, nearest the lake, about 30 feet high, is caused by the Encrinal beds (limestone); the second, by a hard shale; the third, by the Tully limestone; and the fourth, by the Portage. In Paines Creek near Aurora the Tully and Portage have been eroded away, leaving the Encrinal and the hard calcareous shales of Zone D at Moonshine to form the fall. In the creeks at Farleys the upper hard limestone capping the Marcellus shale, Zone B, forms the falls.

GENERAL GEOLOGY.

The lake section.—In traveling from the village of Cayuga to Ithaca one passes over and can collect from, (1) the Eurypterus beds (Rondout limestone or Waterlime), (2) black gypsum (probably Rondout limestone), (3) Stromatopora beds (Manlius limestone^a), (4) Oriskany sandstone (this formation has a maximum thickness here of 4 feet 10 inches and thins out to nothing in less than a mile, leaving the Onondaga (Corniferous) in contact with the Lower Helderberg), (5) Onondaga limestone, (6) Marcellus shales, (7) Hamilton shales and impure limestones, (8) Tully limestone, (9) Genesee shale, (10) Portage shales and sandstones. (See fig. 1.)

For the purpose of this paper it will not be necessary to speak more fully of any of the formations mentioned above, with the exception of the Hamilton.

Hamilton formation.—The description of the shales and limestones of the Hamilton formation is given in detail in the description of the different zones which make up this formation. In general it may be said that the Marcellus shales immediately above the Onondaga limestone (where they are very black and fine) alternate with eight or ten layers of impure limestone for a distance of 10 feet. The shale becomes harder and sandy toward the top and closes with a very hard, impure limestone. The Marcellus, as

^a Memoir New York Mus., Vol. III, No. 3, Oct., 1900, pp. 8-9.

California High 1917

Compton





shown by a recent well boring, is 81 feet thick. Above this limestone are the shales of Zone C, several hundred feet thick, which are very soft, with occasionally a harder, more calcareous, or sandy layer, and several courses of concretions. The thick, impure limestone or hard calcareous shale, Zone D, which overlies the soft shales of Zone C, is very marked because of its hardness and richness in fossils. Immediately above this zone and in contact with it is a layer of shale 50 feet thick, as fine and black in the lower part as the Marcellus shale. Above this the calcareous Hamilton shales continue to the Encrinal, becoming somewhat harder as the Encrinal is approached.

Encrinal bed.—The Encrinal is a crystalline limestone about $1\frac{1}{2}$ feet thick. Above this the Upper Hamilton or Moscow shales extend to the Tully limestone. The Upper Hamilton shales vary greatly in hardness and faunal combination.

Concretionary layers.—Concretions appear not far from the Encrinal beds. These concretionary layers are at first shaly, but in the Cayuga Lake section become progressively more calcareous as the Tully limestone is approached.

The persistence of the concretionary layers was observed for some distance. One course, which contained *Leiorhynchus laura* and *Orbiculoidea lodiensis media* (Zone V), was observed at Shurger Glen, Lake Ridge, and King Ferry, a distance of 12 miles. These concretions could not be identified in the Seneca Lake section. The thin layer of limestone under the Tully, included in Zone Y, was noted at these places also. Both the limestone layers and the fossils of Zone Y were wanting in the Seneca Lake region. Zone H at King Ferry, containing small upright concretions, with a characteristic fauna, was found also in Paines Creek, 5 miles north. The extent of the Encrinal beds and hard calcareous shales of Zone D is spoken of in another place (pp. 82-83).

Jointing.—The jointing of the rock in this whole region is exceptionally well developed. The joint planes have a direction of N. 20° - 30° W. and S. 5° - 15° E., and are almost vertical. (See Pl. II.) This jointing accounts, in large measure, for the perpendicular faces of the falls and cliffs which are so noticeable in this region.

Tully fold.—As one goes up the lake from Union Springs the general dip of the rock to the south is very noticeable, the different strata continuing for some distance and then disappearing under the lake. Using the Tully as a reference plane,^a it was found that from King Ferry to Lake Ridge the strata descend about 45 feet to the mile. To the south the Tully limestone takes a horizontal position and remains a little above lake level for about 3 miles. It there rises into an arch over 6 miles long, with its highest point at least 235 feet above the lake. From this point south the dip is very rapid, varying from a

^aDip of rocks in central New York, by S. G. Williams: Am. Jour. Sci., 3d series, Vol. XXVI, 1883, pp. 303-306.

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maximum of 400 feet to the mile, the average being 110 feet. Vanuxem^a noticed this fold, and explained it as an apparent but not a real fold, reasoning that since the strata dipped southward the bend of the lake to the east would cut into the strata and give the appearance of a fold. The direction and amount of dip of the strata are such that the bend in the lake could not alone have produced such an arch, although it undoubtedly had some effect. The folds along Seneca Lake and the fault in the outlet of Keuka Lake, which are in a west-of-north direction from the Cayuga Lake arch, point to the explanation that this whole region suffered a lateral pressure sufficient to crumple the strata, thus forming a long fold of which the arch at Cayuga Lake and the undulations in the strata at Seneca Lake are a part. The impure limestone of Zone D is so folded that the creek cuts through it twice before it reaches the fall at Moonshine. In Big Gully Creek the limestone which caps the Marcellus shales is cut through by the stream before it reaches the fall; it also makes a fold to the south, forming falls in two small streams.

The fact that the region is not faulted, that the folds are easily seen, and that the creeks cut through the glacial drift into the shales, makes the collecting especially easy, and reduces to the minimum the liability to error in locating the horizons in different sections. The difficulties in the way of making accurate measurements with the instruments at hand were such that all measurements given are only approximate.

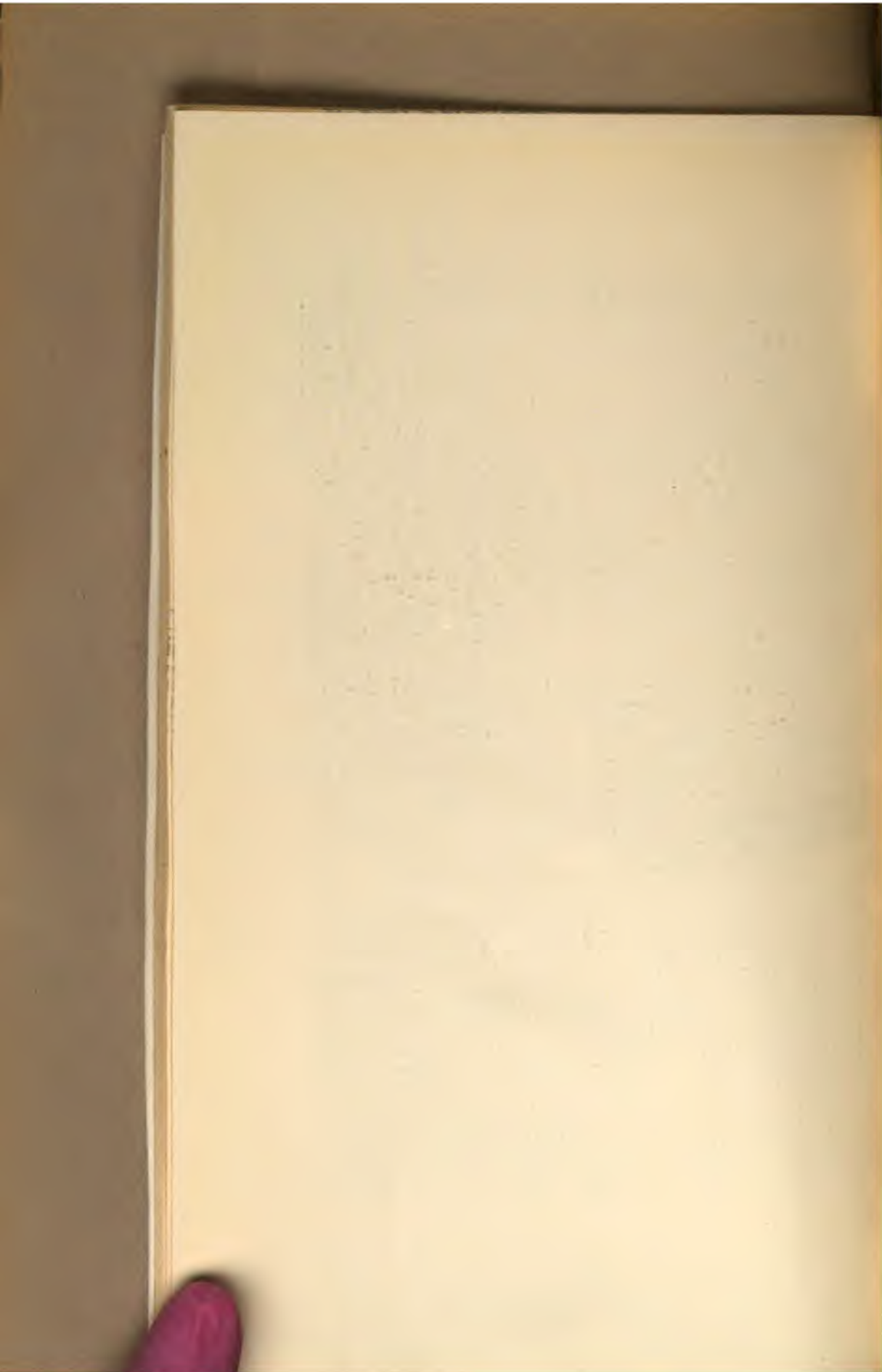
^aGeology of New York. Survey of the third district, 1842.



JOINTING IN UPPER HAMILTON SHALE AT SHURGER GLEN.

The stream falls over Tully limestone.

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CHAPTER II.

HISTORY OF THE HAMILTON FORMATION.

McClure.—The first American geologist, William McClure, published a geological map of the United States in the Transactions of the American Philosophical Society in 1809. In this map "he struck out the ground outline of geographical geology."^a The line separating the "Primitive rocks" from the "Floetz, or secondary," followed the Oneida and Mohawk rivers of New York to the Hudson River. All the country between the Alleghenies and a line running north and south through the western boundary of Arkansas, with the exception of a narrow strip along the Gulf of Mexico, is marked as Floetz, or secondary, and embraces, in a general way, the formations from the Silurian to the Pleistocene.^b

Eaton.—Amos Eaton after, for that time, considerable travel and observation, published An Index to the Geology of the Northern States in 1820, and later, under the patronage of Stephen Van Rensselaer, made a geological survey of the district adjoining the Erie Canal. These observations he published in 1824.^c

Werner.—These pioneers in geology were followers of Werner, who attempted to correlate the strata in America with those of Europe as described by the German geologist. As Werner depended entirely upon the lithological character of the strata for his correlations (the value of fossils in correlation not being known at that time) great confusion resulted.

Early attempts at correlation.—Since the Old Red sandstone of England is a conspicuous formation, both McClure and Eaton took it as a convenient reference plane. Eaton first correlated it with the Catskill sandstone (Devonian) and the Triassic sandstone of the Connecticut River. McClure considered the Red sandstone of the Medina group (Silurian) and the Triassic sandstone of the Connecticut River as the equivalent of the Old Red sandstone of Europe. In 1824 Eaton concluded that "the 'Old Red sandstone' rests on the Metalliferous graywacke [Utica and Hudson River group] and underlies the Millstone grit" [Oneida conglomerate of the Medina group]; that is, that the Old Red sandstone (Devonian) should be correlated with a portion of the Medina sandstone, thus placing the greater part of the Upper Silurian and the Devonian in the Carboniferous.

Search for coal.—After the decision was reached that the Red sandstone of the Medina was equivalent to the Old Red sandstone (Devo-

^aIndex to the Geology of the Northern States, by Amos Eaton, 1820, p. viii.

^bTrans. Am. Philos. Soc., Vol. VI, 1809, pp. 411-428.

^cGeological and Agricultural Survey of the District adjoining the Erie Canal.

nian) of England which underlies the coal, Eaton expected to find coal in some of the formations in the southern part of the State, and advised the people who lived south of the Medina sandstone to dig for coal wherever there were any indications. Eaton's belief that what we now know to be the Devonian was Carboniferous was strengthened by the finding of thin layers of carbonaceous matter in what, from the localities mentioned, must have been the Marcellus and Genesee shales. This coal in very thin layers is occasionally found in these horizons. Because of this advice a great deal of money was wasted in a vain search for coal.

The different formations of the Devonian were not distinguished by Eaton. The "third graywacke" or "pyritiferous rocks" included all the formations above the Onondaga. His description of this "rock" as a calcareous or siliceous gray rock, with aluminous cement, either slaty or in blocks and rich in fossils, and the localities, the end of Cayuga Lake and the south shore of Lake Erie, between its eastern extension and Sturgeon Point, does not distinguish between the different formations. The Hamilton in the Cayuga Lake locality was not included, as is shown by the fact that the Tully was mistaken for the Onondaga (Carboniferous) limestone.

Conrad and Hall.—In 1837 Conrad gave as the object of the New York State survey the stratigraphical and economic study of the various rock formations. The attention of his assistants was directed to the "mineral and fossil contents" of the rock, as the fossils "serve to determine with much accuracy the geological age and character of the strata."

In 1838 Hall considered the rocks of western New York as belonging to the Devonian and Carboniferous. His reason for believing this, he says, rested chiefly on the study of the organic remains, especially of the vertical distribution of the trilobite.^a

Conrad, in the same report, concluded that the rocks of New York, with the exception of the Catskill, terminated with the Upper Ludlow rocks of Murchison [Upper Silurian].

In the section along the Genesee River, given in the same report, the shales between York and Mount Morris are marked as "limestone shales." This was one of the first attempts to separate the rocks above the Onondaga (Carboniferous) in New York State into finer divisions.

In the Fourth Annual Report, 1840, Hall compared the fossils from the New York strata with those of England and correlated the Catskill with the Old Red sandstone [Devonian] of England; the Chemung to Moscow shales [Upper Hamilton], inclusive, with the Upper Ludlow rocks [Upper Silurian]; and the Ludlowville [Lower Hamilton] and Marcellus shales with the Lower Ludlow rocks [Upper Silurian], and adopted the name Ludlowville to show this correlation.

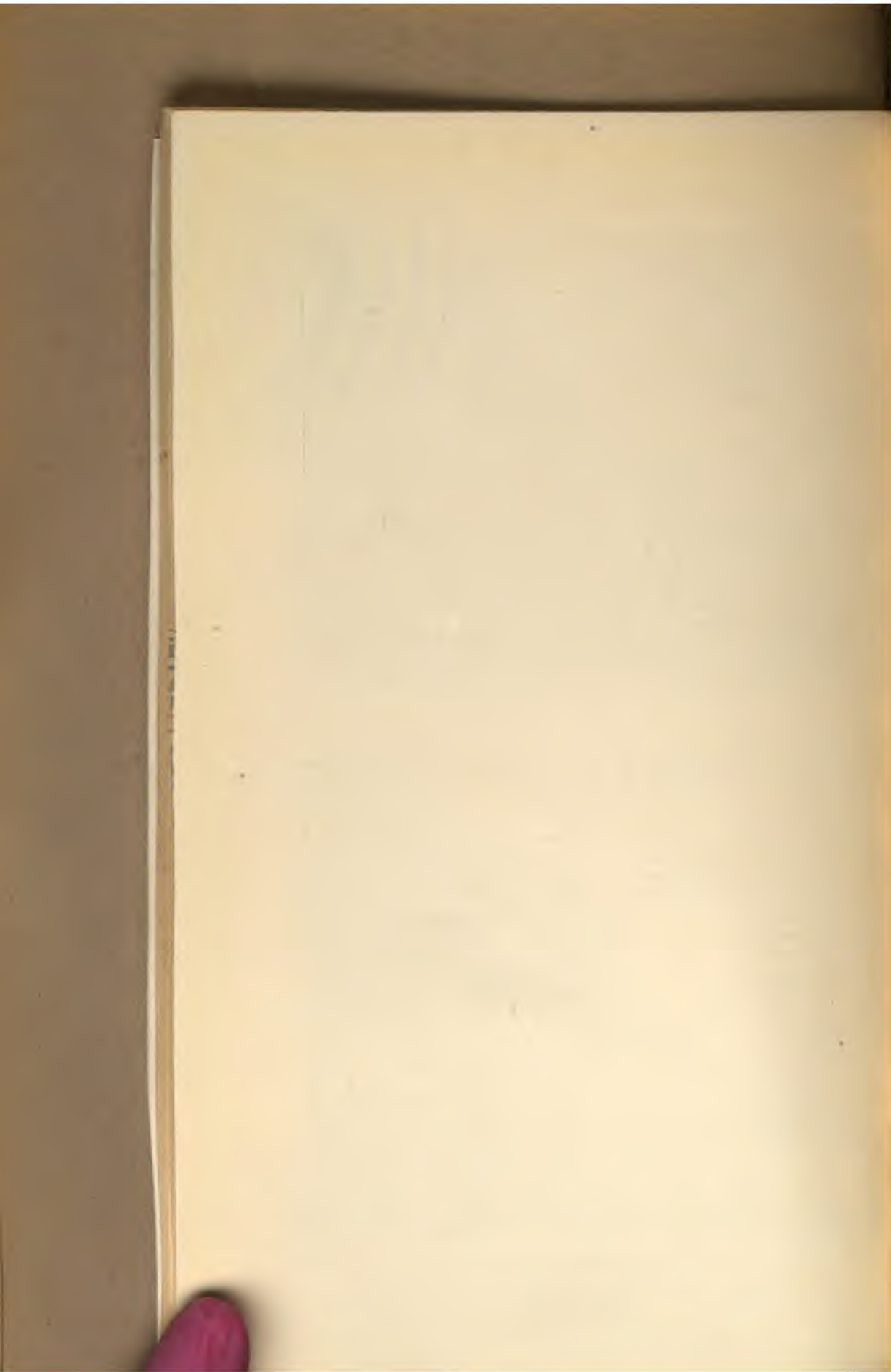
^a Second Ann. Rept. New York Geol. Survey, 1838, p. 291.



A. TULLY LIMESTONE, SOUTH OF SHURGER GLEN.



B. ENCRINAL BED, SOUTH OF SHURGER GLEN, SHOWING DIP TO THE SOUTH.



The report of 1841 placed the Hamilton (called Sherburn group and shales near Apulia) and Marcellus (called Black shale) in the Aymes-try [Upper Silurian]. According to this correlation the "Lower Lud-low rock" closed with the Onondaga (Corniferous) limestone.

Verneuil's correlation.—In his concluding remarks on Verneuil's Parallelism of the Paleozoic Deposits of America with those of Europe,^a Hall says that the "line of demarcation between the Devonian and Silurian is at the base of the Upper Helderberg or at the bottom of the Schoharie grit. Verneuil proposed to unite the Marcellus shale, Hamilton shale, Tully limestone, and Genesee shale in one division, and make the Portage and Chemung the second of this period. He correlated the Chemung, Portage, Genesee, Tully, and Hamilton with the formations of Eifel and Devonshire; the Mar-cellus with the shales of Wissenbach in Nassau.

Renevier's correlation.—In the second edition, 1896, of the *Tableau des Terrains Sédimentaires formés pendant des Époques de la Phase Organique du Globe Terrestre*, by Professor Renevier, the Marcellus and Hamilton are taken together and considered to have been deposited at the same time as the *Tentaculites* shales (lower part) of Thuringia and Bohemia, Wissenbacher slates, and the schists "à Phacops Potieri de Bretagne."

Williams's correlation.—The line separating the Meso- and Eo-Devonian in America was determined by Prof. H. S. Williams to be at the base of the Tully limestone. Previously the Tully had been included in the Meso-Devonian. The reason for this correlation is as follows:^b

The conclusions we draw from this study of the faunas of the Cuboides zone and the Tully limestone are that within narrow limits, geologically speaking, the point in the European time scale, represented by the beginning of the deposition of the Cuboides Schichten of Aix la Chapelle, etc., is represented in the New York sections by the Tully limestone, and, second, that the representative of the fauna of the Cuboides zone of Europe is seen in New York not only in the Tully limestone, but in the shaly strata for several hundred feet above. Therefore, if we wish to express precise correlation in our classification of American rocks, the line between Middle and Upper Devonian formations should be drawn at the base of the Tully limestone, to correspond with the usage of French, Belgian, German, and Russian geologists, who include Frasnien, Cuboides Schichten, and correlated zones in the Upper Devonian.

The Meso-Devonian must therefore be considered as bounded above by the Tully and below by the Onondaga (Corniferous).

South American Hamilton.—The sandstone of Erere in Brazil, a portion of the Huamampampa sandstone of Bolivia, and a portion of the formations of the Jachel River in central Argentina are correlated with the New York Hamilton. These correlations were determined chiefly by the presence of *Vitulina pustulosa* and *Tropidoleptus carinatus*.

^a Am. Jour. Sci., 2d series, Vol. V, pp. 176-183, 356-370; Vol. VII, pp. 45-51, 218-231.

^b Williams, Bull. Geol. Soc. America, Vol. I, 1890, pp. 481-500.

CHAPTER III.

DESCRIPTIONS OF THE FOSSILIFEROUS ZONES.

The Hamilton formation, including the Marcellus shales, is in this region, as shown by the Ithaca well section, 1,224 feet thick.^a It is bounded above by the Tully and below by the Onondaga (Corniferous) limestone.

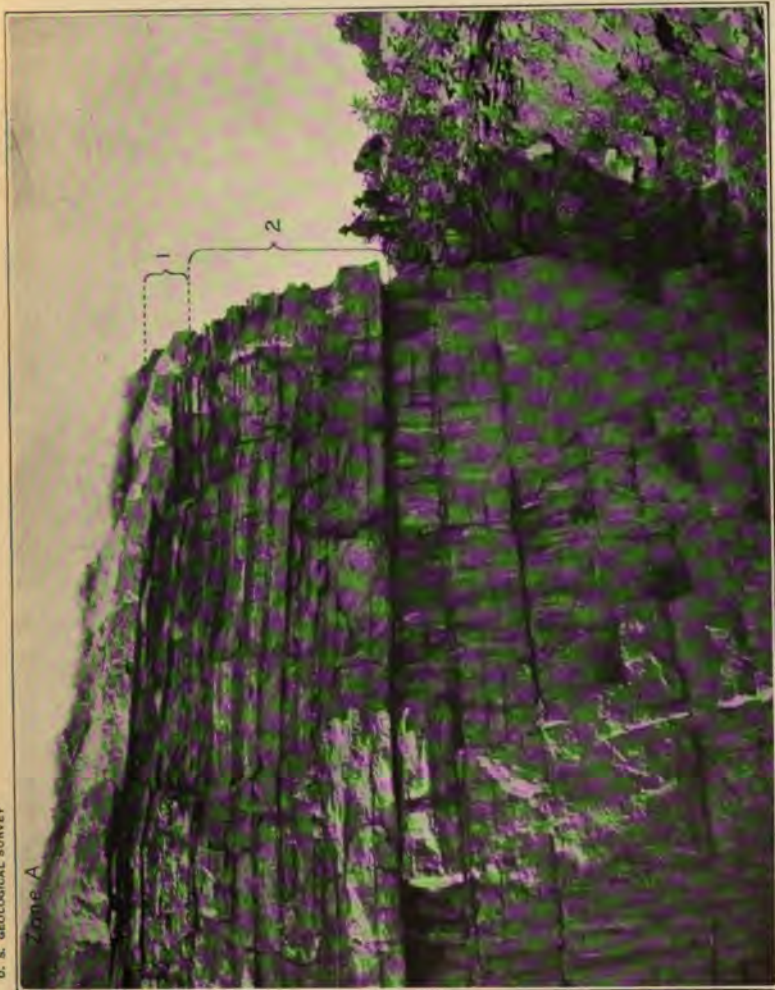
The Cayuga Lake section has been divided into twenty-five zones, each zone having been determined by its contained fauna. When, in working up the section, there seemed to be a change in the fauna or the character of the rock, a provisional division was made, the total number of such divisions being seventy-six. Later, in working up the material in the laboratory, it was found necessary to combine many of these divisions, reducing the number to twenty-five.

The name of each zone is the name of the group, genus, or species which seems especially characteristic of the faunule of that zone. The name chosen is not necessarily that of the most abundant species unless that species is, as far as our present knowledge goes, associated with a definite group of fossils. For example, the three *Leiorhynchus* zones have a faunal resemblance which can not be mistaken, although in the first *Leiorhynchus* zone *Leiorhynchus limitare* is the characteristic species, while in the other two zones the species is *Leiorhynchus laura*. It is also true, that *Leiorhynchus laura* may be associated with an abundance of *Orbiculoidea lodiensis media*, as in Zone V. In the first and second *Ambocælia umbonata* zones a group of species occurs which is often found associated together when *Ambocælia umbonata* is abundant. In every zone the fauna is more or less modified by species from lower zones continuing on, and by local conditions, but the essential character of the fauna is determined by the environmental conditions.

A. HAMILTON-ONONDAGA (CORNIFEROUS) ZONE.

Stratigraphy.—This faunule at Cayuga Lake was found in a layer 2 inches thick, almost completely made up of poorly preserved fossils. The shale which held them together was composed of finely comminuted fossils, principally tentaculites. Between this zone and the Onondaga (Corniferous) limestone are eight or ten alternations of impure limestones and fine sooty shale, aggregating 12 feet (see

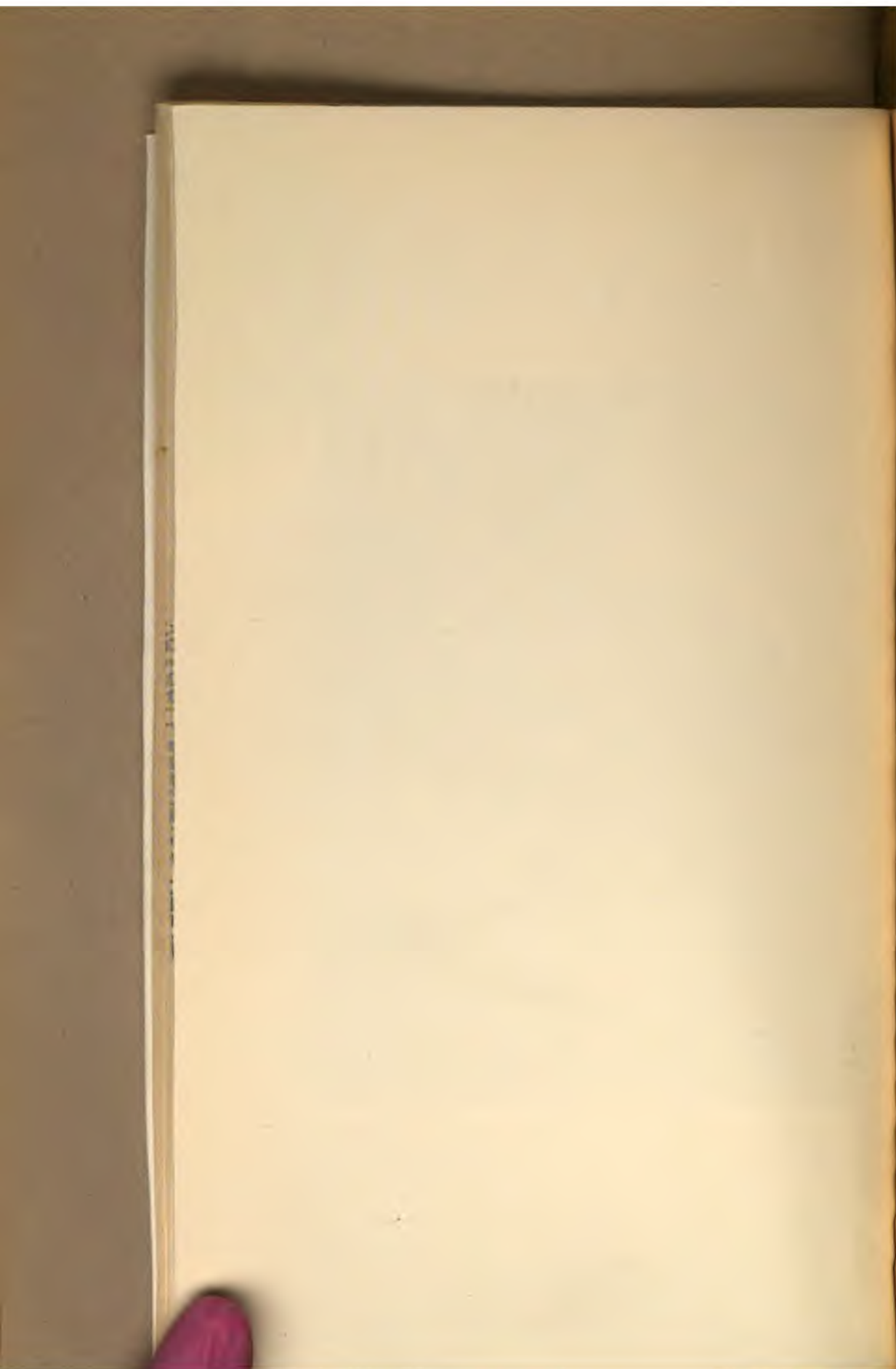
^aProsser, Am. Geologist, Vol. VI, 1890, pp. 199-211.



ALTERNATION OF IMPURE LIMESTONES AND SHALES ABOVE THE ONONDAGA BEDS AT UNION SPRINGS.

Zone A: 1, Goniatite bed; 2, impure limestones and shales; 3, Onondaga limestone.

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Pl. IV). Two feet below this zone is a limestone layer (Goniatite limestone), which is purer than any of the layers between it and the

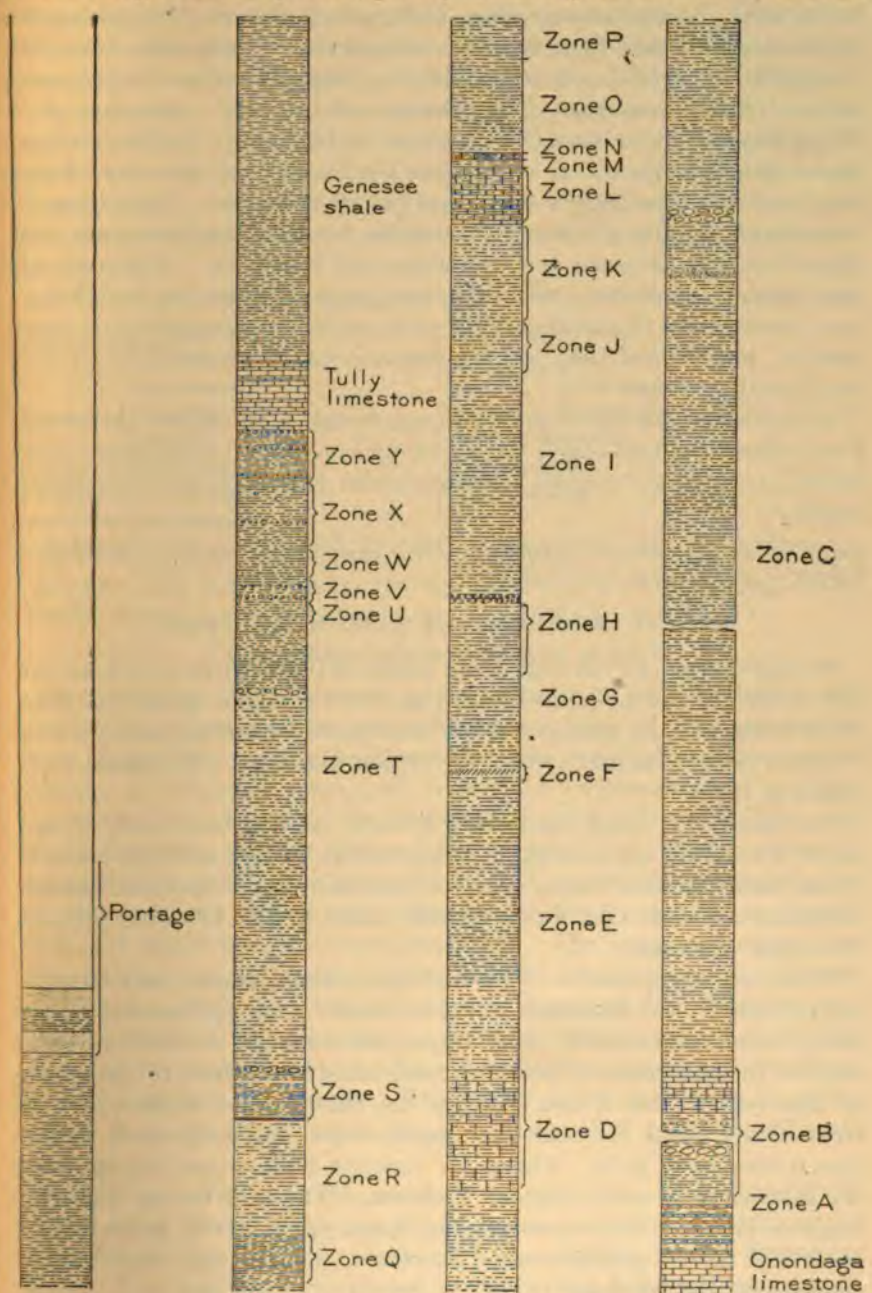


FIG. 2 - Zones in Cayuga Lake section.

Onondaga limestone. Below and above Zone A the shale is very rich in *Styliola fissurella* and *Tentaculites*.

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Faunule.—The faunule of this zone is a mixture of Onondaga and Hamilton species, of which Brachiopoda make up the greater part. It contains *Chonetes mucronatus*, *Ambocoelia umbonata*, *Tropidoleptus carinatus*, and other Hamilton species, together with *Spirifer macrus*, *Anoplothea camilla*, *Chonetes lineatus*, and *Phacops cristata* var. *pipa* of the Onondaga. The absence of *Chonetes coronatus* and *Tropidoleptus carinatus* below this level (12 feet above the Onondaga) shows that the Hamilton must have been developed elsewhere for a long period of time before the deposition of this zone. The fauna is remarkable in that it is not a transition between the Onondaga and Marcellus, but between the Onondaga and Hamilton. Although all the species mentioned, with the exception of *Chonetes coronatus*, have been found in the Marcellus, they are not characteristic of that horizon, but most of them are the common fossils of richly fossiliferous Hamilton zones.

A faunule of similar composition was found in an impure limestone 9 feet above the Onondaga limestone, at Livonia. This faunule contained *Anoplothea camilla* associated with Hamilton and Onondaga fossils.^a

Locality.—South of Union Springs, 12 feet above the Onondaga. Layer of gray shale 2 inches thick.

B. FIRST LEIORHYNCHUS ZONE (Marcellus shale).

Stratigraphy.—In the first creek south of Great Gully Creek, in the bed of the stream near the mouth, and in the shale along the lake shore south of this, flattened spherical concretions occur, many being 3 feet in horizontal and 1½ feet in vertical diameter. No fossils were found in them.

The Marcellus shale closes with a hard, impure limestone, 4½ feet thick, which is very noticeable in the creeks in this vicinity, since it forms falls wherever it occurs. It is important in this section, because it makes a distinct line between the shales of the first and second *Leiorhynchus* zones.

With the exception of 2 feet of bituminous shales immediately above Zone A, the Marcellus shales between Union Springs and Great Gully Creek are covered. It is impossible to make an accurate estimate of the thickness of this zone because of the folding of the strata in this region. At Union Springs the Onondaga is folded, and at Great Gully Creek the limestone layer of the Marcellus is so folded that it forms two falls. This same stratum folds to the south, making the rise of ground south of Levanna. The well boring recently made at Ithaca (1900) shows the fine black shale of the Marcellus to be 81 feet thick. It is probable, therefore, that the total thickness is between 80 and 100 feet.

Faunule.—The faunal combination of this zone does not differ materially from that of the second and third *Leiorhynchus* zones with

^aJ. M. Clarke, Forty-seventh Ann. Rept. N. Y. State Mus., pp. 327-352.

the exception of the replacement of *L. limitare* by *L. laura*. In the lower portion of the zone the shale is extremely fine, and the abundance of *Styliola* and *Tentaculites* much greater than in the other *Leiorhynchus* zones. The shales become coarser and the fossils more abundant (with the exception of *Tentaculites* and *Styliola*) as Zone C is approached. The fauna of the upper portion is especially rich in *Orthoceratites*. About 2 feet below the limestone is a nodular layer extremely rich in *Leiorhynchus limitare* in an excellent state of preservation. The shale for 2½ feet below the limestone is very calcareous and coarse, but still contains *L. limitare* and its characteristic fauna.

A *Leiorhynchus* fauna has approximately the following composition:

Leiorhynchus { <i>laura</i> , <i>limitare</i> .	Leiopoteria <i>lævis</i> .
Chonetes { <i>mucronatus</i> , <i>scitulus</i> , <i>lepidus</i> .	Nuculites { <i>triqueter</i> , <i>oblongatus</i> .
(<i>Orbiculoidea media</i>).	Nucula <i>corbuliformis</i> .
<i>Strophalosia truncata</i> .	<i>Styliola fissurella</i> .
<i>Lunulicardium fragile</i> .	<i>Tentaculites</i> .
	<i>Phacops rana</i> .

Locality.—Near the mouth of the creeks between Levanna and Farleys. The best exposure for the upper portion is in Great Gully Creek; for the lower, the quarries south of Union Springs.

C. SECOND LEIORHYNCHUS ZONE.

Stratigraphy.—This zone is quite uniform in its lithological and faunal characters with the exception of one layer of dark calcareous shale about 15 feet above the Marcellus shale, which contains a greater number of *Phacops rana* and *Ambocelia umbonata* than is usual elsewhere in the section. As a rule the shale is fine and seldom contains more than eight or nine species to each 5 feet. Two courses of concretions occur 70 feet below Zone D. Occasionally a harder layer occurs; but, with the exception mentioned, the species do not change with this slight change in sedimentation. The lower and upper portions of this zone were worked more carefully than the middle portion.

Faunule.—This zone, which is several hundred feet thick, is very poor in fossils. The faunule is one which usually occurs in the fine shales of the Hamilton stage where the conditions were not favorable to a rich Hamilton faunule. The make-up of the fauna is given under Zone B. This same faunule is reported from the Livonia section.

Localities.—Paines Creek, south of Aurora, from Moonshine Falls to the lake; Deans Creek, north of Aurora, from Goulds Falls to the lake; Great Gully Creek, south of Union Spring, to the Marcellus shale. It is also finely developed in the Seneca Lake section.

D. FIRST TEREBRATULA ZONE (Basal limestone of Clarke).

Stratigraphy.—Because of its hardness, compared with the soft shales above and below, this zone forms a fall in all of the creeks

where it appears. Moonshine Falls, on Paines Creek, and the fall in Deans Creek, on the farm of James Gould, are from 30 to 40 feet high. The rock is a hard calcareous shale, almost an impure limestone. The fauna as well as the lithological character separates this zone sharply from the shales above and below. It is 25 feet thick in Paines Creek.

Faunule.—The genera of this section are not, by any means, the most common fossils in this zone; but since they are associated with a peculiar combination of species, both here and at Eighteenmile Creek, the name *Terebratula* has been used to designate that combination. The combination of species spoken of above is *Cryptonella planirostris*, *C. rectirostris*, *Meristella haskinsi*, *Eunella lincklani*, *Spirifer divaricatus*, *Vitulina pustulosa*, and in the Encrinal, in addition or by substitution, *Centronella impressa*.

This is the first and only zone in which *Heliophyllum halli* appeared in any numbers. The locality was, however, especially favorable for collecting, on account of the great area of the zone exposed by the folding of the strata and the consequent wearing away of the soft upper shales in several places by the action of the water. One specimen of *H. confluens* was obtained from the Encrinal beds at Black Rock, on Paines Creek, and one specimen of *H. halli* from a doubtful locality in the Upper Hamilton. With these exceptions no specimens of this genus were found above or below Zone D. *Vitulina pustulosa* is common, and was found in the same abundance in the Encrinal beds, but not elsewhere in the section.

The shale of this zone is extremely fossiliferous. The total number of species found was 84; of these, 32 are Pelecypoda, 33 Brachiopoda, 4 Gasteropoda, 3 trilobites, 3 corals.

Localities.—Paines and Deans creeks on the east side of Cayuga Lake; Slate Rock Run on west side of Seneca Lake. D. F. Lincoln^a reports it from Bentons Run, west side of Seneca Lake; north of Days Landing; Readers Creek; West Fayette station; 1 mile west of West Bearytown; 1 mile southeast of Bearytown; Big Hollow Creek east of Romulus. Clarke reports it from Canandaigua Lake and Flint Creek.

NOTE.—This zone is well exposed in Slate Rock Run on the west side of Seneca Lake. In this locality it is 15 feet thick and contains a faunule very similar to that of the Cayuga Lake region. The principal difference noted was the greater abundance of cyathophylloid and Favosite corals. The common fossils of this zone in Slate Rock Run are:

Heliophyllum halli.
Cystophyllum americanum.
Favosites.
Chonetes mucronatus.

Eunella lincklani.
Rhipidomella vanuxemi.
Crinoid stems.
Stropheodonta inaequistriata.

^aAnn. Rept. State Geol. New York, 1884.

E. THIRD LEIORHYNCHUS ZONE.

Faunule.—Immediately above the calcareous shales of Zone D occur 55 or 60 feet of very fine black shales which are extremely barren of fossils. This is especially true of the lower 25 feet, in which but ten species were found, the complete faunule being twenty-seven species. *Styliola fissurella* and ostracods occur abundantly in thin layers, but in the body of the shale they are seldom seen. With few exceptions the ostracods and styliolæ do not reappear in this section above this zone and never again in abundance.

The change of sedimentation from a firm calcareous to a fine black mud was evidently a condition unfavorable to the rich faunule of Zone D, and either (1) it was replaced by migration of a faunule similar (recurrent) to that of the shales below Zone D or, what seems probable, (2) the species found in Zone E, which were inconspicuous in the faunule of Zone D, lived on while their less adaptable neighbors perished. The shales of this zone contain no brachiopods and only three species of pelecypods—and they are rare—which are not found in Zone C. They contain one brachiopod and two pelecypods which are not found in Zone D. The faunule of this zone bears a strong resemblance to the "recurrent fauna" of Ontario County.^a

Localities.—Above and in contact with Zone D in Paines and Deans creeks, on Cayuga Lake, and in the Seneca Lake section.

NOTE.—The shales of this zone are of this same character west of Seneca Lake. The resemblance to the Marcellus is so strong that Mr. Berlin H. Wright^b called the shales of this zone in the Kashong Creek section "Marcellus." The lithological character and the faunule are both very much like that of the Marcellus, with the exception of *Leiorhynchus limitare*, which the writer did not find in the Kashong section.

F. MICHELINIA ZONE (Provisionally).

Stratigraphy.—This zone is not separated from the lower shales by any distinct line, the division being made by the abundance of the fossils and change in species. It terminates in a more calcareous layer 4 inches thick, in which *Michelinia stylopora* is common. The number of species is not great except by comparison with the zones above and below. Compared with E and G the species are in the ratio (E) 29:(F) 50:(G) 23. The thickness of the zones, in feet, is in the ratio (E) 55:(F) 5:(G) 18.

Faunule.—The only common species are *Tropidoleptus carinatus*, *Nucula corbuliformis*, *Cypriocardella bellistriata*, *Michelinia stylopora*, and erinoid stems. *Grammysia constricta*, *Ceratopora dichotoma*, and *Michelinia* appear for the first time. *Tropidoleptus carinatus* is very common, but of small size.

Location.—Paines Creek, 60 feet above Moonshine Falls. Five feet thick.

^aJ. M. Clarke, Ann. Rept. State Geol. New York, 1884, pp. 9-22.

^bThirty-fifth Ann. Rept. New York State Mus., 1882, pp. 195-200.

G. CHONETES VICINUS ZONE.

Stratigraphy.—This zone comprises the firm shales below the falls nearest the lake, at King Ferry, and the upper portion of the section on Paines Creek; 23 species; 18 feet thick.

Faunule.—*Chonetes vicinus*, which appeared in Zone F, became very abundant and of large size in this zone. *Tropidoleptus carinatus* is common. *Lunulicardium fragile* and *Cypricardella bellistriata* are found occasionally. The shales are not so barren as the small number of species would indicate, although they are by no means rich in fossils.

Locality.—King Ferry and Paines Creek.

NOTE.—Later investigation shows that the name *Chonetes vicinus* does not express a faunal combination. The zone is a distinct one at King Ferry, but is an expression of peculiar local conditions rather than a normal faunule. This zone was not found in the Kashong Creek section.

H. TRANSITION ZONE.

This zone does not have a distinctive faunule and is probably a transition between Zones G and I.

Locality.—King Ferry, N. Y.

I. FIRST CYPRICARDELLA BELLISTRIATA-ATHYRIS SPIRIFEROIDES ZONE.

Faunule.—The abundance of *Cypricardella bellistriata*, *Athyris spiriferoides*, and *Spirifer pennatus* is characteristic of this faunule. The relative abundance of all of the species in the zone changes somewhat from the bottom to the top. *Tropidoleptus* is common in the lower third, rare in the middle, and common again in the upper third. *Pholidostrophia iowaensis* appears for the first time in the lower third and was not common elsewhere in the section.

Location.—King Ferry, above the first falls; 47 feet thick.

NOTE.—The faunule of the shale 25 feet below the Encrinal beds, 19 feet thick in the Kashong Creek (Seneca Lake) section, bears a stronger resemblance to Zones I and K than to J, but the faunule as a whole has a different facies. It resembles I in the abundance of *Tropidoleptus carinatus* CA, *Chonetes mucronatus* CA (instead of *C. vicinus*), and *Spirifer pennatus*. It differs in the scarcity of *Cypricardella bellistriata* and *A. spiriferoides* and in the abundance of Bryozoa and crinoid stems. The 25 feet of shale immediately underlying the Encrinal is very poor in fossils, the faunal combination of which is not plain.

J. TELLINOPSIS ZONE.

Faunule.—This faunule differs from that of Zones K and I in its paucity of spirifers, *Athyris spiriferoides* and *Tropidoleptus carinatus*

and in the abundance of *Ambocælia umbonata*, *Tellinopsis subemarginata*, and *Modiomorpha*. There is one thin layer of *Ambocælia umbonata* and *Chonetes scitulus*. The shale of Zone J is finer than that of Zone K and more fossiliferous.

Locality.—King Ferry, 20 feet below the Encrinal beds; 10 feet thick.

K. SECOND CYPRICARDELLA BELLISTRIATA-ATHYRIS SPIRIFEROIDES ZONE.

Faunule.—This faunule is a recurrence of Zone I, with slight modifications. The numerous individuals of the upper third of Zone J are the characteristic fossils of K with the exception of *Chonetes vicinus*. Other species of *Chonetes* are common and balance the loss of *C. vicinus*. The abundant species of Zone I are most common in Zone K. This zone resembles Zone X of the Upper Hamilton, except that in Zone X *Leiorhynchus laura* continues from Zone V.

Locality.—King Ferry, extending down from the Encrinal for 22 feet.

L. SECOND TEREBRATULA ZONE (ENCRINAL BEDS).^a

Stratigraphy.—The Encrinal bed includes 8 feet of calcareous shales, impure limestone, and 1½ feet of crystalline limestone, with an abundance of crinoid stems in the upper part.

Faunule.—Of the 47 species occurring in this bed, 14 are from the crystalline limestone. No fossils are abundant. Of the 7 species which are common 3 are distinctive; *Vitulina pustulosa* is found also in D; *Centronella impressa* occurs here for the first time and does not appear again; *Eunella lincklaeni* is found also in D and Y; *Spirifer divaricatus*, one fragment, is found in D; *Nucleospira concinna* is rarely found in the section, and *Spirifer granulosus* reappears here. (For discussion of Encrinal see Chapter V.)

Locality.—This zone, called also the Encrinal bed, includes the crystalline Encrinal beds and impure limestone and shales, 8 feet in all, found in the creeks between Shurger Glen and Aurora.

M. ORTHONOTA ZONE.

Faunule.—This zone differs decidedly from that above and below in the composition of its fauna. A glance at the accompanying table (Pl.V) will show the distinctness of this zone. The common Pelecypoda are *Phthonia nodicostata*, *Orthonota undulata*, *Prothyris lanceolata*, and *Tellinopsis subemarginata*.

Locality.—Shurger Glen. A rather fine shale 1½ feet thick underlying a harder layer (Zone N) which forms a small falls 2½ feet high a short distance from the fall over the Encrinal.

^aIncluding the genera of Section A; cf. Schuchert: Bull. U. S. Geol. Survey No. 87, p. 124.

N. (TRANSITION ZONE.)

Zone N is a rather hard, limy layer, 6 inches thick, which forms the capping for a falls $2\frac{1}{2}$ feet high. The faunule is not a distinct one. The abundance of *Tropidoleptus carinatus* places it with the zone which follows, while the fewness of *Chonetes* and abundance of erinoid stems and Bryozoa places it with the preceding faunule. It is lithologically distinct, but must be called a transition faunule.

O. CHONETES ZONE.

Faunule.—The abundance of *Chonetes mucronatus* and *C. scitulus* is very noticeable. In a fine shale, 3 inches thick, is an abundance of *Spirifer pennatus* and *Tropidoleptus carinatus*. A hard, argillaceous, sandy layer above this is very rich in *S. pennatus*. This zone is not well marked, and is probably very local.

Locality.—Shurger Glen. Coarse and rather sandy strata overlying the hard layer forming the small fall; 10 feet thick.

P. FIRST AMBOCÆLIA ZONE.

Faunule.—There is little difference between this zone and Zone R except that there is a greater abundance of individuals in the latter. *Ambocælia umbonata* and *Phacops rana* are abundant and *Pholidops hamiltoniæ* and *Chonetes mucronatus* are common. Pelecypods, with the exception of *Palæoneilo constricta*, are rare. The association of *P. rana* and *A. umbonata* is seen in thin layers throughout the section. (See under *A. umbonata*, Chapter IV.)

Locality.—Twenty feet above the Encrinal beds at Shurger Glen; 5 feet thick.

Q. CHONETES LEPIDUS ZONE (rather barren shales).

Faunule.—The 15 feet of thin shale of which this zone is composed is very barren both in individuals and in species, the upper 5 feet being extremely so. Only 16 species were found in the entire bed; of these 6 species are found in the upper 5 feet and 12 species in the lower 10 feet. In the upper 5 feet *Chonetes lepidus* and *A. umbonata* are the only common fossils.

The conditions in this region during the deposition of these shales were very unfavorable to life. At first the fauna was rather large, but at last the two species mentioned above were almost the only ones that were able to survive. The conditions were not unlike those which existed during the deposition of the muds forming Zone E. The effect of the unfavorable environment is seen in the small size and number of individuals.

Locality.—Shurger Glen. Twenty-five feet above the Encrinal beds and 20 feet below the concretionary layer of Zone S.

R. SECOND AMBOCCELIA ZONE.

Stratigraphy.—This zone is bounded above by the *Stropheodonta*-Coralline zone and below by fine shale. It is a very marked zone in the Shurger Glen section. Large blocks of shale which have fallen from the cliff are almost completely made up of *Ambocælia umbonata*, with many *Phacops rana* in an excellent state of preservation.

Faunule.—Besides *A. umbonata* and *P. rana*, *Pholidops hamiltoni* and *Palæoneilo constricta* are very common. *Chonetes mucronatus* is often found. A comparison of "the fauna of the *Spirifer consobrinus* fauna, Da" of Grabau^a with this zone shows that (1) the relative position and (2) the faunule are the same. (See under *Ambocælia umbonata*.)

Locality.—Shurger Glen and King Ferry, 40 feet above the Encrinal beds. Underlies the concretionary layer of Zone S. Twenty-five feet thick.

NOTE.—A bed with a fauna of this same composition occurs in the Kashong section. The resemblance is so striking that it can not be mistaken. It is about 80 feet above the Encrinal beds in this section and but 40 feet at Shurger Glen. The zones of the two sections may be continuations of the same bed, but there is no evidence to that effect except the character of the faunule and the rock.

S. STROPHEODONTA—CORALLINE ZONE.

Stratigraphy.—This zone includes the lowest concretionary layer in which the concretions are of large size. The concretions are shaly, but the shale in which they are embedded is rather more calcareous than usual. The fossils occur in three or four layers, about 2 or 3 inches thick. In these thin fossiliferous layers the shale weathers into a mud, leaving the fossils conspicuous. In the lower part of the zone occurs a very thin layer composed almost entirely of crinoid joints.

Faunule.—The rarity of *Ambocælia umbonata* and the abundance of Bryozoa and crinoids, together with *Stropheodonta inaequistriata*, *S. concava*, *Rhipidomella vanuxemi*, and corals in considerable numbers, make this zone distinct from that above and below.

Locality.—Shurger Glen, 60 feet above the Encrinal beds. In a concretionary layer 10 feet thick.

NOTE.—Thin layers containing this faunule commence 40 feet below the Tully at Kashong Creek (Seneca Lake), and occur frequently for 30 feet. The common fossils are:

<i>Spirifer pennatus</i> .	<i>Atrypa reticularis</i> .
<i>Stropheodonta inaequistriata</i> .	<i>Streptelasma rectum</i> .
<i>Stropheodonta concava</i> .	<i>Amplexus</i> sp.?
<i>Stropheodonta junia</i> .	Crinoid stems.

This faunule responded very quickly to certain conditions, as is shown by its frequent occurrence in the Seneca and Cayuga lake sections. It also has a very constant faunal combination.

^a Sixteenth Ann. Rept. State Geol. New York, 1898, p. 319.

T. MODIELLA PYGMÆA ZONE.

Stratigraphy.—The shale in this zone is compact and fairly uniform throughout. It is not very fossiliferous, but by no means barren, except where thin layers of fine shale occur.

Faunule.—This is distinctly a pelecypod zone in which small pelecypods, such as *Nucula*, *Modiella*, *Palæoneilo*, and *Tellinopsis* are common. *Leiopteria* is frequently found near the center of the zone. The total number of species in the zone is large because of the occasional appearance of a number of rare species. The number of species of brachiopods are to those of pelecypods as 27 to 39. Of the brachiopods, *Spirifer pennatus* and *Ambocælia umbonata* are found in all parts of the zone, sometimes being very common. *Stropheodonta*, *Nucleospira*, and *Reticularia* are absent. *Nucula*, *Nuculites*, *Modiella*, and *Palæoneilo*, which are rare in the lower zones, become common in this zone, though never abundant. The faunule disappears with the appearance of *Leiorhynchus laura* and *Orbiculoidea*.

Locality.—Shurger Glen, 40 feet below the Tully limestone. A *Septaria* layer is embedded in the upper few feet of this zone. The total thickness is 98 feet.

U. AMBOCCELIA PRÆUMBONA ZONE.

Faunule.—This is a transition zone between T and V. It is characterized by the commonness of *A. præumbona*, which appeared a foot below this for the first time in this section, and in the reappearance of *Spirifer tullius*, which, until within a foot of this zone, was not present in the shale below for 20 feet. The faunal combination is not plain.

Locality.—Shurger Glen. Underlies the concretionary layer of Zone V. Five feet thick.

NOTE.—A bed in the Kashong (Seneca Lake) section contains the following species:

Ambocælia præumbona.
Leiorhynchus laura.

| *Orbiculoidea lodiensis media*?
| *Chonetes mucronatus.*

This faunule is probably a continuation of that at Cayuga Lake.

V. ORBICULOIDEA OR MODIFIED LEIORHYNCHUS ZONE.

Leiorhynchus laura and *Orbiculoidea lodiensis media* in abundance in a fine shale make this a very distinct zone. It may be considered a *Leiorhynchus* zone with *Orbiculoidea lodiensis media*, modified by the addition of *S. tullius* and *Ambocælia præumbona*. In the center of the zone, however, the faunule is, with the addition of *O. lodiensis media*, an almost typical *Leiorhynchus* fauna. The *Leiorhynchus laura* and *Orbiculoidea lodiensis media* are very large and in an excellent state of

preservation in the concretionary layer, which is embedded in the fine shale of this zone. These concretions are over a foot in horizontal diameter.

Locality.—Shurger Glen, Salmon River, Lake Ridge, King Ferry, 30 feet below the Tully limestone.

W. (TRANSITION ZONE.)

Faunule.—The abundance of *Rhipidomella vanuxemi* and *Phacops rana*, which are rare in the next zone above, and the frequency with which *Pholidops hamiltoniae* and *Dalmanites boothi* occur, present the appearance of a somewhat distinct faunule. However, *Chonetes mucronatus*, *Leiorhynchus laura*, *Spirifer audaculus*, *Stropheodonta junia*, and *S. perplana* are common to both.

The faunule can not be taken as a part of either Zone V or Zone X, although it contains a number of species of each, nor can it be considered a separate zone. During its deposition the conditions permitted the migration of a *Spirifer-Atrypa* faunule, together with *R. vanuxemi* and *P. rana*, and at the same time were not unfavorable to some of the species of the *Orbiculoides* faunule.

Locality.—Shurger Glen. In a pyritiferous concretionary layer, 23 feet below the Tully, 10 feet thick.

X. SPIRIFER-ATRYPA ZONE.

Faunule.—*Atrypa reticularis*, *Athyris spiriferoides*, and *Spirifer audaculus* occur here in very great abundance. *S. granulosus* has a greater development than in any other portion of the section. *Leiorhynchus laura* is less abundant than in the zone below and is not found in the *Cystodictya* zone. Bryozoa, which were rare in Zone W, begin to be abundant and continue in great numbers to the Tully limestone.

Locality.—Shurger Glen. Nine feet below the Tully limestone.

Y. CYSTODICTYA ZONE.

Stratigraphy.—The Hamilton stage closes with this zone, which includes an alternation of limestone and limy shales and a nodular layer. This condition is seen at Ludlowville, Lake Ridge, and King Ferry.

Faunule.—The zone is rich in Bryozoa, especially *Cystodictya incisurata*, and crinoid stems. *Tropidoleptus carinatus* is the fossil most often seen in the upper portion. *Spirifer pennatus* and *S. audaculus* are very common, while *S. marcyi* is represented by well-preserved specimens in the calcareous shales 5 feet below the Tully limestone. Pelecypods are very rare in the upper few feet. This, with a slight modification, is the same as the *Cystodictya* faunule of Grabau, which at Eighteenmile Creek occurs in the Lower Hamilton.

Locality.—Shurger Glen, Salmon Creek, Lake Ridge. In contact with the Tully limestone.

NOTE.—The Hamilton formation in the Kashong Creek section, Seneca Lake, closes with a fine shale 7 feet thick, very much like the Genesee in appearance and very poor in fossils.

The faunule of this zone is:

Ambocœlia umbonata.
Pholidops hamiltoniæ.
Phacops rana.
Tropidoleptus carinatus.

Ostrocods.
Palæoneilo constricta.
Tellinopsis submarginata.

EXPLANATION OF DIAGRAMS, PL. V.

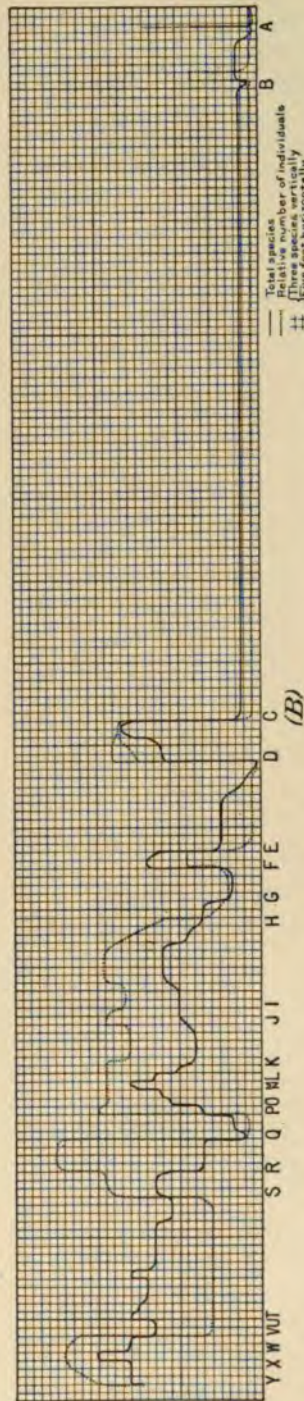
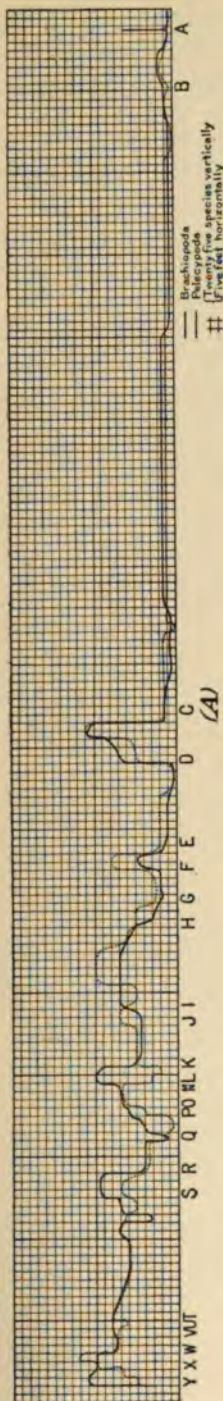
Diagram A.—With the exception of Zone A, 2 inches thick, 12 feet above the Onondaga (Corniferous) limestone, which is very rich in individuals, the number of species of Pelecypoda and Brachiopoda is very uniform throughout the soft shales until Zone D is reached. A few feet of the Upper Marcellus shales are quite fossiliferous, but the number of species is not large. The concretionary layer of Zone C contains a faunule fairly rich in individuals, but poor in species.

As indicated by the angle, Zone D is sharply defined from the shales above and below by the great abundance of species and individuals as well as by the greater hardness of the rock. With the exception of a portion of Zone X, the lower 10 feet of Zone D contains more species of both Brachiopoda and Pelecypoda than the same number of feet in any other part of the section. In the lower portion of the zone the brachiopods and pelecypods are represented by an equal number of species. In the upper portion both decrease in the number of their species, but the lamellibranchs suffer the greater loss.

The most barren shales of the section above Zone D, both in individuals and in species, are the 5 feet of fine black shales immediately in contact with it. The black shales of this zone (E) are very noticeable.

Zone F, which is a coralline zone, is rich in species, especially of pelecypods. After reaching a low point in Zone G there is a rapid increase in pelecypods, the increase in brachiopods remaining almost uniform throughout Zone I, while the pelecypods reach a high point in the center of the zone, but fall below the Brachiopoda toward the upper portion.

The next noticeable change is in the Encrinal bed, Zone L, where the pelecypods are extremely rare, while the brachiopods have a rich development. The brachiopods gradually decrease in the number of species until Zone Q is reached, where there is a greater paucity than in any other zone in the Upper Hamilton. The pelecypods become common in Zones O, M, and N, but become rare in species in Zone Q. In the 35 feet above Zone Q there is an increase, which culminates in Zone S, the brachiopods being predominant. Above Zone S to Zone



A. DIAGRAM SHOWING RELATIVE ABUNDANCE OF PELECYPODA AND BRACHIOPODA IN THE CAYUGA LAKE SECTION.
B. DIAGRAM SHOWING RELATIVE ABUNDANCE OF INDIVIDUALS AND SPECIES IN THE CAYUGA LAKE SECTION.

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X, with one local exception, the number, both of pelecypods and of brachiopods, is quite uniform. In Zone X the pelecypods reach their greatest development in the section, the brachiopods also being well toward their highest point.

The impure limestones of the upper few feet, with which the Hamilton formation closed, seemed unfavorable for pelecypods, as was the case in the Encrinal beds, and very favorable for brachiopods. From Zone X the pelecypods decrease and the brachiopods increase to the contact with the Tully limestone.

Diagram B.—The abundance of individuals is represented only approximately, as there is no practical method of determining accurately the actual number of individuals to each 5 feet.

In the fine shales of the Marcellus are thin layers full of *Styliola* and *Tentaculites* (these are not represented in the diagram). Above Zone A, which is very rich in individuals, the shale is almost barren as far up as it was exposed at this station (Union Springs), with the exception of *Tentaculites* and *Styliola*. For a few feet below the limestone with which the Marcellus closes there is an abundance of individuals of *Leiorhynchus limitare* and of *Orthoceratites*. The shales above this limestone, Zone C, are almost barren in many places, but now and then a fossil is found. Occasionally a thin layer of fine shale a fraction of an inch thick contains *Leiorhynchus laura* or *Strophalosia truncata* in great numbers.

In Zone D the impure limestone which forms the capping of Moonshine Falls seemed richer in individuals than the lower shales of this zone. This may, however, have been due to the more favorable collecting because of the weathering out of the fossils. Above Zone D are a few feet of almost completely barren shales, Zone E; above these shales the remaining 30 feet of Zone E continues poor in individuals and species to Zone F. In Zone F there is a sudden increase in the number of species and individuals, which makes it a quite distinct zone. The number of individuals, however, did not increase in the same ratio as the species. From Zone G to the middle of Zone I there is a rather gradual increase in species and individuals. From this point the number of species decrease to the Encrinal beds, while the number of individuals vary. The species become abundant in the upper part of the Encrinal bed and decrease to Zone Q, in which the shale is more barren, in species and individuals, than in any other zone in the Upper Hamilton.

The great abundance of individuals of the Zones P and R is shown. Zone R is, according to the diagram, the most fossiliferous zone (in individuals) in the section, although the number of species is by no means large.

From Zone S to Zone W there is a rather regular increase in the number of species, while the number of individuals is rather small. Zone S is rich in number of species as well as in abundance of indi-

viduals. Zone V, the *Orbiculoidea* zone, is separated from the other zones not only by its faunal combination, but in the fewness of its species; the number of individuals is not greatly different from that of the shale below. Zone X is the richest in species of any zone in the section. The abundance of individuals is great in proportion. Zone X was worked more thoroughly than any other except Zone Y—a fact which will in a measure account for the large numbers of species and individuals in the collection. From this zone to the Tully limestone the total number of species becomes less.

PAUL COLEMAN 1904

CHAPTER IV.

ANNOTATED LIST AND CLASSIFICATION OF SPECIES FOUND IN
THE HAMILTON FORMATION OF THE CAYUGA LAKE SEC-
TION.

Subkingdom COELENTERATA.

Class ANTHOZOA-ACTINOZOA.

The members of this class are, with a few exceptions, rare in the Cayuga Lake section. They are, however, of considerable importance since, when they are common, they are associated with a peculiar combination of species.

Subclass TETRACORALLA Haeckel.

Family ZAPHRENTIDÆ E. & H.

Genus STREPTELASMA Hall.

1. *Streptelasma rectum* Hall.

Ill. Dev. Fos. Hall, 1876, pl. 19.

This is the commonest of the corals at Cayuga Lake. It is chiefly confined to the upper 150 feet of the section. When it occurs with *Stropheodonta* it has a definite faunule.

Genus ZAPHRENTIS Rafinesque.

2. *Zaphrentis simplex* Hall.

Ill. Dev. Fos. Hall, 1876, pl. 21.

Four specimens of this species were found in the *Cystodictya* zone (Y).

Genus AMPLEXUS Sowerby.

3. *Amplexus* sp. undet.

Ill. Dev. Fos. Hall, 1876, pl. 3.

Next to *Streptelasma* in abundance is a species of *Amplexus*, found principally in the *Modiella* zone (T). It differs from the figures of *A. hamiltonie* and *A. intermedius*. The coral is very much flexed and has a jointed appearance, the constrictions sometimes being very marked.

Family CYATHOPHYLLIDÆ E. & H.

Genus HELIOPHYLLUM Hall.

4. *Heliophyllum halli* E. & H.

Ill. Dev. Fos. Hall, 1876, pl. 23.

This species is restricted to Zone D, with the exception of a single specimen from a doubtful locality in the Upper Hamilton. A number of specimens were obtained, two of the largest of which measured 220 and 270 mm. in length and 65 mm. in diameter. *H. halli* is very common in the "Basal limestone" of Ontario County, and is confined to a narrow zone within a few feet of the Encrinal beds in the Eighteenmile Creek section.

This species is very common in the "Basal limestone" of the Seneca Lake section.

5. *Heliophyllum confluens* Hall.

Ill. Dev. Fos. Hall, 1876, pl. 26.

A single specimen was found in this section—in the Encrinal beds of Paines Creek. At Eighteenmile Creek *H. confluens* is also restricted to the Encrinal beds.

Genus DIPHYPHYLLUM Lonsdale.

6. *Diphyphyllum archiaci* Billings.

Geol. Sur. Mich., vol. 3, 1873-1876, p. 126, pl. 47.

This species was found in Zone Y. A cross section showed the characteristic arrangement of the septa.

Subclass HEXACORALLA Haeckel.

Suborder TABULATA E. & H.

Family FAVOSITIDÆ E. & H.

Genus FAVOSITES Lamarck.

7. *Favosites argus* Hall.

Ill. Dev. Fos. Hall, 1876, pl. 13.

One specimen from Zone Y is probably of this species. It is of very much the shape of fig. 2, pl. 13, of the "Devonian Fossils." The arrangement of the large and small cells can not be made out.

8. *Favosites* sp. undet.

Favosite corals from several zones were too imperfectly preserved for specific identification. They did not show any of the specific characters of *F. argus*.

Genus MICHELINIA de Koninck.

9. *Michelinia stylopora* Eaton.

Ill. Dev. Fos. Hall, 1876, pl. 18.

This species is common in Zone F, but nowhere else in the section. At Eighteenmile Creek it is restricted to a few feet at the base of the Lower Hamilton. At Kashong Creek very large specimens of this species occur in a narrow bed 13 feet above the "upper fall" (above Encrinal). A few specimens were also found in the "Basal limestone" of Slate Rock Run.

Genus TRACHYPORA E. & H.

10. *Trachypora* (*Dendropora*) *ornata* Rominger.

Geol. Sur. Mich., vol. 3, 1873-1876. p. 62, pls. 23-24.

A few well-marked fragments of this species were found in the *Cystodictya* zone (Y), and in the Encrinal band. This species is not uncommon in the shales forming the falls below the Encrinal in the Kashong Creek section.

Family AULOPORIDÆ Nicholson.

Genus AULOPORA Goldfuss.

11. *Aulopora serpens* Goldfuss.

Geol. Sur. Mich., 1873-1876, p. 81, pl. 33.

Two very imperfect fragments of this species were found.

Genus CERATOPORA Grabau.

12. *Ceratopora dichotoma* Grabau.

Proc. Bos. Soc. Nat. His., vol. 23, 1899, p. 418, pl. 4.

This species, with well-marked characters, was found in Zones F and O. Excellent specimens also occur above the Encrinal at Kashong Creek.

Family SYRINGOPORIDÆ E. & H.

Genus SYRINGOPORA Goldfuss.

13. *Syringopora* sp. undet.

Geol. Sur. Mich., vol. 3, 1873-1876, p. 79.

A colony of this genus 10 or 12 feet long and 5 to 8 inches in thickness occurs in the lower part of Zone D. The specific characters are not distinct enough to warrant a specific identification. The "Basal limestone" of the Slate Rock Run (Seneca Lake) contains many colonies of this coral.

Family CHÆTETIDÆ E. & H.

Genus CHÆTETES Fischer.

14. *Chætetes fruticosa* Hall.

Ill. Dev. Fos. Hall, 1876, pl. 38.

A few specimens of this species were obtained from the upper portion of the Upper and Lower Hamilton.

Other species of *Chætetes* were found, but were too imperfect to permit of definite identification.

Subkingdom ECHINODERMATA.

Class CRINOIDEA Miller.

With the exception of three poorly preserved specimens, the crinoids are represented by crinoid joints and a very few plates. No other class of Echinodermata was found.

Genus GRANATOCRINUS Troost.

15. *Granatocrinus* (*Pentremilis*) *leda* Hall.

Fifteenth Rept. N. Y. State Mus. Nat. Hist., 1862, p. 149, pl. 1.

A complete but badly crushed specimen of this species was found in Zone O. Radial plates were obtained from Zones T and I.

Genus ANCYROCRINUS Hall.

16. *Ancyrocrinus bulbosus* Hall.

Fifteenth Rept. N. Y. State Mus. Nat. Hist., 1862, p. 90, pl. 1.

A specimen of this species was found in Zone L.

Genus DICHOCRINUS Münster.

17. *Dichocrinus* sp.?

A body without arms, from Zone I, was doubtfully referred to this genus.

18. Crinoid stems and plates.

The centers of abundance of crinoids, as is shown by the stems, joints, and plates, are, in this section, in Zones D, F, L, M, N, S, and Y. For a faunal study a record of these crinoid remains is as important as the record of any other fossil.

Bryozoa flourished when the conditions were favorable to the development of crinoids. The only exception is Zone F.

Subkingdom VERMES.

Suborder TUBICOLA.

Genus SPIRORBIS Daudin.

19. *Spirorbis angulatus* Hall.

Fifteenth Rept. N. Y. State Mus. Nat. Hist., p. 84.

A few casts of this tube were found on an *Orthoceras* in the upper Marcellus.

Subkingdom MOLLUSCOIDEA.

Class BRYOZOA Ehrenberg.

A number of genera and species of Bryozoa not included in the following list were found. The great amount of time necessary to make accurate identifications, together with the imperfect condition of these fossils, made a more complete list impossible. The centers of abundance of this class are Zones D, L, S, and Y.

Order GYMNOLÆMATA Allman.

Suborder CYCLOSTOMATA Busk.

Family DIASTOPORIDÆ Busk.

Genus HEDERELLA Hall.

20. *Hederella canadensis* Nicholson.

Pal. N. Y., vol. 6, 1887, p. 277, pl. 65.

A mass of this parasitic bryozoan was found in Zone Y.

Genus REPTARIA Rolle.

21. *Reptaria stolonifera* Rolle.

G. B. Simpson, Handbook N. A. Pal. Bry., p. 599, pl. 25.

This species was found in the Marcellus shale incrusting an *Orthoceras*, and in Zone Y incrusting a goniatite. It is rare in this region.

Suborder CRYPTOSTOMATA Vine.

Family CYSTODICTYONIDÆ Ulrich.

Genus TÆNIOPORA Nicholson.

22. *Tæniopora exigua* Nicholson.

Pal. N. Y., vol. 6, 1887, p. 263, pl. 62.

A few specimens of this species were obtained from Zone Y. It is very rare here, and is so reported from Eighteenmile Creek.

Genus *CYSTODICTYA* Ulrich.23. *Cystodictya incisurata* Hall.

Pal. N. Y., vol. 6, 1887, p. 241, pl. 40.

This is by far the most abundant bryozoan in the section. In Zone Y almost every piece of shale contains a fragment. It is common in the "*Stictopora* zone" of Grabau at Eighteenmile Creek.

Family FENESTELLIDÆ King.

Genus *POLYPORA* McCoy.24. *Polypora multiplex* Hall.

Rept. State Geol. N. Y., 1886, p. 66, pl. 11.

A specimen of this species showing the cellular face was found in Zone S. A great many specimens showing the noncellular face may be of this genus and species, but can not be positively identified as such.

25. *Bryozoa*, undet.

The distribution of *Bryozoa* is given under crinoid stems.

Class BRACHIOPODA.

The classification of Brachiopoda, as given by Schuchert in Bulletin No. 87 of the United States Geological Survey, is used throughout this paper.

Adjustment to environment.—It was found in the study of the faunules of the Hamilton formation that the Brachiopoda were, as a rule, more closely adjusted to their environment than the Pelecypoda. This is shown in the greater definiteness of the faunule combinations of the Brachiopoda and in the often sudden disappearance of every abundant species, and even genera, with an apparently slight change of sedimentation, and their equally sudden reappearance upon the substitution of favorable conditions. The table of faunal zones at the end of the paper makes further comment unnecessary.

Order ATREMATA Beecher.

Superfamily LINGULACEA Waagen.

Family LINGULIDÆ Gray.

Genus *LINGULA* Bruguière.26. *Lingula delia* Hall.

Pal. N. Y., vol. 4, 1867, p. 12, pl. 2.

Zone V (*Orbiculoidea* zone) contains excellent specimens of this species, fully 25 mm. in length and 16 mm. in width. It is rare in every part of the section, but is occasionally found between Zone D and Zone Y.

27. *Lingula densa* Hall.

Pal. N. Y., vol. 4, 1867, p. 11, pl. 2.

A specimen from Zone T was more closely related to this than to any other species described by Hall. It measured 12 mm. in length and 8 mm. in width.

28. *Lingula ligea* Hall.

Pal. N. Y., vol. 4, 1867, p. 7, pl. 1.

Three specimens from Zones I, X, and Y, 4 mm., 4 mm., 9 mm. in length and 2 mm., $2\frac{1}{2}$ mm., and 5 mm. in width, respectively, were referred to this species.

Genus DIGNOMIA Hall.

29. *Dignomia alveata* Hall.

(*Lingula alveata*) Pal. N. Y., vol. 4, 1867, p. 12, pl. 2.

One plainly marked specimen of this species was found in the Encrinal. The same species is reported from the upper portion of the Upper Hamilton at Livonia.

Order TELOTREMATA Beecher.

Superfamily RHYNCHONELLACEA Schuchert.

Family RHYNCHONELLIDÆ Gray.

Genus CAMAROTÆCHIA Hall and Clarke.

30. *Camarotæchia congregata* Conrad.

(*Rhynchonella congregata*) Pal. N. Y., vol. 4, 1867, p. 341, pl. 54.

This species is very rare, being found in but four zones. The specimens are few and so poorly preserved that it is difficult to make a specific identification with certainty.

31. *Camarotæchia dotis* Hall.

(*Rhynchonella dotis*) Pal. N. Y., vol. 4, 1867, p. 344, pl. 54A.

In the crystalline limestone of the Encrinal bed, Zone L, a number of specimens possessing the characteristics of this species were found.

32. *Camarotæchia horsfordi* Hall.

(*Rhynchonella horsfordi*) Pal. N. Y., vol. 4, 1867, p. 339, pl. 54.

This species was found in the Encrinal bed and in Zone Y.

33. *Camarotæchia prolifica* Hall.

(*Rhynchonella prolifica*) Pal. N. Y., vol. 4, 1867, p. 343, pl. 54A.

Specimens from five zones were referred to this species. The specimens are so crushed that the identification in some cases is doubtful.

34. *Camarotoechia sappho* Hall.

(*Rhynchonella sappho*) Pal. N. Y., vol. 4, 1867, p. 340, pl. 54.

The specimens of this species were well preserved. They were found in the Eneerinal bed, Zone D, and in the *Cystodictya* zone (Y).

Genus HYPOTHYRIS King.

35. *Hypothyris cuboides* Sowerby.

Pal. N. Y., vol. 8, pt. 2, 1893, p. 200, pl. 60.

(*Rhynchonella venustula*) Pal. N. Y., vol. 4, 1867, p. 346, pl. 54A.

Nodules almost completely made up of this species were found embedded in the shale on the contact with the Tully limestone. This species was of considerable importance in correlating the Tully limestone with the Upper Devonian of Europe. The occurrence of this species in the Hamilton shales at Cayuga Lake shows that, in this region at least, the migration took place while the muds of the Hamilton formation were still soft, and that the conditions were very favorable for a rapid development.

Genus LEIORHYNCHUS Hall.

This genus appeared to be well adapted to conditions unfavorable to all but a few species. In this section it is always found in greatest abundance where other species are rare. The fine muds of the first, second, and third *Leiorhynchus* and the *Orbiculoidea* zones were especially favorable for its development. The change of species of this genus between the Marcellus (*L. limitare*) and the Hamilton (*L. laura*) did not materially affect the faunules.

36. *Leiorhynchus laura* Billings.

(*L. multcosta* Hall) Pal. N. Y., vol. 4, 1867, p. 358, pl. 56.

This species attains its greatest size and abundance in the *Orbiculoidea* zone (V). In this zone one specimen from a concretion measured 28 mm. in length and 27 mm. in width. Another concretionary layer in the second *Leiorhynchus* zone (C) afforded large, perfect specimens. It is found throughout the section in thin layers of fine shale. These layers, which are a fraction of an inch thick, are occasionally almost entirely made up of flattened specimens. This is especially true of the first, second, and third *Leiorhynchus* zones. This species appears immediately above the limestone capping the Marcellus shale. Although *L. limitare* is very abundant below this limestone, it does not appear above it. Several doubtful specimens found in Zone E had somewhat the appearance of *L. dubium* Hall.

37. *Leiorhynchus limitare* Vanuxem.

(*L. limitaris*) Pal. N. Y., vol. 4, 1867, p. 356, pl. 56.

In the Cayuga Lake section this species is confined to the Marcellus shale. It is preserved in an almost perfect condition in the concretions underlying the falls in Great Gully Creek, near Farleys post-office.

Superfamily TEREBRATULACEA Waagen.

Family CENTRONELLIDÆ Hall and Clarke.

Genus CENTRONELLA Billings.

38. *Centronella impressa* Hall.

Pal. N. Y., vol. 4, 1867, p. 402, pl. 61A.

A considerable number of specimens of this species preserved the exterior and interior of the dorsal and the exterior of the ventral valve. The average size is about 14 mm. in length and 11 mm. in width. This rare but strongly marked species is restricted to the Eocerinal bed (Zone L) at Cayuga Lake, and is found only in the Eocerinal at Eighteenmile Creek.

Family TEREBRATULIDÆ Gray.

Subfamily MEGALANTERINÆ Waagen.

Genus CRYPTONELLA Hall.

39. *Cryptonella planirostris* Hall.

Pal. N. Y., vol. 4, 1867, p. 395, pl. 61.

A single individual of this species was found in the upper portion of Zone D. At Eighteenmile Creek it is found commonly in the Eocerinal and rarely in two zones in the Lower Hamilton.

40. *Cryptonella rectirostris* Hall.

Pal. N. Y., vol. 4, 1867, p. 394, pl. 61.

The specimens of this species are all somewhat flattened and bear a resemblance to *Eunella lincklaeni*. They are, however, more angular and the beak is not so much incurved as in *E. lincklaeni*. They are restricted to Zone D. At Eighteenmile Creek this species is found in a calcareous bed near the base of the Lower Hamilton, but nowhere else in that section.

Subfamily TEREBRATULINÆ Dall.

Genus EUNELLA Hall and Clarke.

41. *Eunella lincklaeni* Hall.

(*Cryptonella lincklaeni*) Pal. N. Y., vol. 4, 1867, p. 397, pl. 60; vol. 8, pt. 2, p. 290.

This species is restricted to Zones D, L, and the upper portions of X and Y. The specimens are often exfoliated, but are not crushed and can readily be identified. It is not reported from Livonia or Eighteen-mile Creek.

Family TEREBRATELLIDÆ King.

Subfamily TROPIDOLEPTINÆ Schuchert.

Genus TROPIDOLEPTUS Hall.

42. *Tropidoleptus carinatus* Conrad.

Pal. N. Y., vol. 4, 1867, p. 407, pl. 62.

The characteristic fossil ranges from the Hamilton-Onondaga zone (A) to the contact of the Tully and Hamilton. In the Cayuga Lake section it seemed to thrive best in the calcareous sediments. Specimens from Zones Y, P, and K measured 25 mm. in length and 30 mm. in width, the average size being 20 by 25 mm.

The occurrence of *T. carinatus* in Zone A shows that the migration of this species must have taken place as early as, and probably during, the oscillation which closed Onondaga and began Marcellus time. The changes in level which ushered in the Marcellus must have been widespread, and it is probable that, at this time, the connection between North America and South America was such that a migration of species was permitted. Rathbun's sandstone of Maecurú and Curuá, which contains *Anoplothera flabellites*, *Vitulina pustulosa* and *Tropidoleptus carinatus*, was correlated with the Marcellus and Onondaga because of the mixture of Onondaga and Hamilton species. Thus far *V. pustulosa* has not been found lower than Zone D, but, accepting Rathbun's correlation, it should be, and may yet, be found as low as *T. carinatus*, if the migration took place at this time.

The only variations noted are between the smaller specimens from the less calcareous shales, which are sometimes almost mucronate, and the large forms of the calcareous shales which are rounded on the cardinal angle. The fact that the young are always less rounded than the older ones indicates that in the finer shales the individuals did not reach maturity.

In eastern New York where the sediments remain of very much the same character throughout the Hamilton and Ithaca groups, *T. cari-*

natus extends into the Chemung. In western New York it disappears with the close of the Hamilton. This species, unlike its associate in South America, *V. pustulosa*, is found in Europe. In North America it has not been reported farther south than Jackson County, Ill.

Superfamily SPIRIFERACEA Waagen.

Family ATRYPIDÆ Gill.

Subfamily ATRYPINÆ Waagen.

Genus ATRYPA Dalman.

43. *Atrypa reticularis* Linnaeus.

Pal. N. Y., vol. 4, 1867, p. 316, pl. 51-53A.

This fossil is not by any means a common one in this section. It is abundant in the upper 25 feet below the Tully limestone and common in the *Stropheodonta*-coralline zone (S). Elsewhere it is seldom seen. The specimens are of the usual form and surface markings.

Family SPIRIFERIDÆ King.

Subfamily SUESSIINÆ Waagen.

Genus CYRTINA Davidson.

44. *Cyrtina hamiltonensis* Hall.

Pal. N. Y., vol. 4, 1867, p. 268, pls. 27 and 44.

This is a rare species throughout the section. It is occasionally found in Zone D, but elsewhere it is rare. At Eighteenmile Creek it is common in a few feet of shale near the top of the Lower Hamilton.

Subfamily TRIGONOTRETINÆ Schuchert.

Genus SPIRIFER Sowerby.

45. *Spirifer audaculus* Conrad.

(*S. medialis*) Pal. N. Y., vol. 4, 1867, p. 227, pl. 38.

The vertical distribution of this species is almost as uniform as that of *S. pennatus*. Hall says that it is an abundant species, coming next to *S. pennatus* in the number of individuals. The greatest abundance of the species, in the Cayuga Lake section, is 20 or 25 feet below the Tully. It is wanting in the second *Leiorhynchus* zone and very rare in the lower half of the Lower Hamilton. The form is very variable. It is impossible to tell in poorly preserved individuals whether the specimens are *S. audaculus* or *S. audaculus macronotus*. At Eighteenmile Creek it has four zones of abundance, two near

the base of the Hamilton, one a foot below and one a foot above the Encrinal. In the intervening space between the zones of abundance the species is either very rare or wanting.

46. *Spirifer audaculus macronotus* Hall.

Pal. N. Y., vol. 4, 1867, p. 231, pl. 38a.

This variety of *S. audaculus* is, in its extreme form, readily distinguished from *S. audaculus*, but the intermediate forms are difficult to determine. In this identification all doubtful forms were called *S. audaculus*.

47. *Spirifer divaricatus* Hall.

Pal. N. Y., vol. 4, 1867, p. 213, pl. 32.

This species was found only in the Encrinal bed (Zone L) and in Zone D. In the former it was not uncommon, but in the latter only one fragment was obtained. The markings of this fossil are so characteristic that there can be no doubt as to the identification. The bifurcating plications and fine imbricating, lamellose striae are seen in all the specimens. It is reported from the 17 feet of soft shales immediately overlying the Encrinal at Livonia, but has not been noted as occurring at Eighteenmile Creek.

S. divaricatus is an Onondaga species which was able to survive the conditions of the Hamilton. Hall and Clarke say that it is the only representative of this type of structure (arrangement of the plications) in the Hamilton faunas, but from the Upper Devonian onward the species multiply rapidly, becoming most abundant and varied in the different faunas of the Lower Carboniferous and continuing until the close of Paleozoic time.

48. *Spirifer granulosus* Conrad.

(*S. granulifera* Hall) Pal. N. Y., vol. 4, 1867, p. 223, pl. 36; vol. 8, pt. 2, p. 39.

In this section the range of this species is from the first *Terebratula* zone (D) to the Tully limestone, a distance of over 400 feet. It is found commonly in but three zones, I, L, and X. At Eighteenmile Creek it is wanting in the shales above the Encrinal beds. In this section it is especially common above and including the Encrinal. This is one of a number of species which show how little one can depend on a single species in correlating the smaller divisions of a formation like the Hamilton. Species which are restricted to the Lower Hamilton at Eighteenmile Creek or Livonia are sometimes restricted to the Upper Hamilton in this section or are found throughout the section, or vice versa.

The characters of the species are quite uniform. The variety described by Hall as *S. clintoni*, but not recognized by Schuchert, was found in Zone T. The measurements are: 75 by 55 mm. for the largest and 35 by 20 mm. for the smallest specimens.

49. *Spirifer marcyi* Hall.

Pal. N. Y., vol. 4, 1867, p. 226, pl. 37.

This spirifer is confined to the upper 15 feet of this section and is most common within 5 feet of the Tully. It is not reported as occurring below the Encrinal in any part of the State. The largest specimen measured 90 mm. in width and 30 mm. in length. No other spirifer found in this section is so well preserved and so striking. This fossil has not been found at Eighteenmile Creek. Clarke reports it in the upper 160 of the Hamilton of the Livonia salt shaft section. It is found in the upper 50 feet of the Upper Hamilton in the Kashong (Seneca Lake) section.

50. *Spirifer pennatus* Atwater.

(*S. mucronata*) Pal. N. Y., vol. 4, 1867, p. 216, pl. 84.

No other species is found so commonly from Zone D to the Tully limestone as is this one. It is wanting only in the fine shales of Zone Q, the 1½ feet of crystalline Encrinal beds, and in Zone E. In the Eighteenmile Creek section it is common below the Encrinal but extremely rare above.

S. pennatus, at Cayuga Lake, is variable in three particulars: (1) Gibbosity; (2) surface markings; (3) in the length of the mucronations. These variations are not progressive. A specimen which is gibbous is usually shorter and has fewer but stronger imbrications than the mucronate and flat kinds. There is no difficulty at any time in distinguishing the extremes of this species as developed at Cayuga Lake from *Delthyris consobrina* on the one hand and *Spirifer audaculus* on the other.

51. *Spirifer tullius* Hall.

(*S. tullia*) Pal. N. Y., vol. 4, 1867, p. 218, pl. 85.

Spirifer tullius is not abundant in any part of the section nor has it a great vertical range. With the exception of five or six specimens, which were found immediately below the Encrinal beds, the species is confined to the Upper Hamilton.

The characteristic fine striations are usually distinct except in the Encrinal, where the shell has been exfoliated in working it out of the limestone. One of the largest specimens from Zone I measured 16 mm. in width and 14 mm. in length. One specimen from Zone I measured 17 mm. in width and 13 or 14 mm. in length.

52. *Spirifer macrus* Hall.

(*S. macra*) Pal. N. Y., vol. 4, 1867, p. 190, pl. 27.

This species was found only in Zone A, 12 feet above the Onondaga (Corniferous) limestone. It is associated with Onondaga and Hamilton fossils. (See Zone A.)

Genus DELTHYRIS Dalman.

53. *Delthyris consobrina* d'Orbigny.

(*Spirifera ziczac*) Pal. N. Y., vol. 4, 1867, p. 222, pl. 35.

Spirifer pennatus occasionally approaches this species in its form and surface markings, the imbricating lamellæ being sometimes strongly arched and finer than normal. The number of plications of *D. consobrina* is, however, always less. In this section there is no difficulty in distinguishing between the extreme forms of the two species. This fossil is fairly common in Zones R and S, but is rare elsewhere in the section. At Eighteenmile Creek it is found only above the Enerinal, where it is restricted to two zones. It is not reported from Livonia.

54. *Delthyris sculptilis* Hall.

(*Spirifera sculptilis*) Pal. N. Y., vol. 4, 1867, p. 221, pl. 35.

This species is not uncommon in a weathered layer of the upper part of Zone D. It was not found elsewhere in the section. At Eighteenmile Creek it occurs only in the Enerinal. At Livonia it is found in two zones above the Enerinal.

Genus MARTINIA McCoy.

55. *Martinia subumbona* Hall.

(*Spirifera subumbona*) Pal. N. Y., vol. 4, 1867, p. 234, pl. 33.

A very few specimens of this species were found in Zone T. The surface markings could not be made out, but the general form was in accord with the descriptions. One specimen measured 15 mm. in length and 15 mm. in width.

Genus AMBOCÆLIA Hall.

56. *Ambocælia præumbona* Hall.

Pal. N. Y., vol. 4, 1867, p. 262, pl. 44.

This species has a very limited vertical range in this section. It is found in Zone U as a center and a foot or two above and below. The specimens are rather smaller than the type specimens, but are quite characteristic. At Livonia it is restricted to the Upper Hamilton, and is common in but one zone, 48 feet thick, the lowest part of which is 17 feet above the Enerinal. It is rarely found above this. At Eighteenmile Creek it is restricted to the 3½ feet at the top of the Upper Hamilton. It might be inferred from its occurrence in these three sections that it is a characteristic Upper Hamilton fossil. In the Kashong (Seneca Lake) section it is restricted to the upper portion of the Upper Hamilton. The fact that it has not been found east of Cayuga Lake or west of New York State indicates that it originated in this region.

57. *Ambocoelia umbonata* Conrad.

Pal. N. Y., vol. 4, 1867, p. 259, pl. 44.

The gregarious character of this species is well shown in a description in one of the old New York reports.^a In speaking of the shale at Eighteenmile Creek, Hall says: "The lower part of this shale resting on the Enerinal beds is completely filled with a small *Orthis* or *Stenecesma* (*Ambocoelia umbonata*). This species so abounds that in some places there is scarcely enough shaly matter to cause the mass to cohere." In the second *Ambocoelia* zone (R), described elsewhere, *A. umbonata* has a remarkable development. Elsewhere in the section layers an inch or less in thickness were found which were almost completely made up of them. In actual numbers there are a great many more *A. umbonata* than any other fossil. It extends from Zone A to Zone Y. Its vertical range is equally great at Livonia and at Eighteenmile Creek. The absence of *Tropidoleptus carinatus* wherever *A. umbonata* flourishes, and vice versa, is noticeable both here and at Eighteenmile Creek. *Phacops rana* is an associated fossil.

The variations of this species are principally confined to surface markings, although variation in size is common.

Dr. J. M. Clarke describes *A. spinosa* from the Livonia section:^b "Surface bearing faint traces of concentric lines and covered with numerous elongate depressions which were probably the bases of insertion of epidermal spines." A number of individuals answering this description fairly well were found in Zone U, but were included with *A. umbonata*. Specimens covered with elongated pits resembling *A. umbonata* var. *nana*,^c described by Grabau, have also been included with *A. umbonata*.

Genus RETICULARIA McCoy.

58. *Reticularia fimbriata* Conrad.

(*Spirifer fimbriata*) Pal. N. Y., vol. 4, 1867, p. 214, pl. 33.

In this section *R. fimbriata* extends from Zone D to Zone Y, but is never abundant. Aside from Zones D, N, and Y it is very rare. At Livonia it is not reported lower than the Enerinal, while at Eighteenmile Creek it does not occur above the Enerinal.

Family ATHYRIDÆ Phillips.

Subfamily HINDELLINÆ Schuchert.

Genus NUCLEOSPIRA Hall.

59. *Nucleospira concinna* Hall.

Pal. N. Y., vol. 4, 1867, p. 279, pl. 45.

This is a rare species in all parts of the section, and although it occurs in the highest zone (Y) and in Zone D, it was found in but two

^a Fifth Annual Report, Geol. Sur. N. Y., 1841, p. 164.

^b Report N. Y. State Geol., vol. 1, 1893, p. 177, pl. 4.

^c Sixteenth Ann. Report State Geol. N. Y., 1898, p. 277.

other zones—S and L. The specimens have either the surface markings preserved or the muscular scars distinct.

At Livonia it is reported as occurring only in a concretionary layer 50 feet above the Encrinal. At Eighteenmile Creek it is very common in the upper foot of the Lower Hamilton.

Genus ANOLOTHECA Sandberger.

60. *Anolotheca camilla* Hall.

(*Cœleospira camilla*) Pal. N. Y., vol. 4, 1867, p. 329, pl. 52.

This species was found at the base of the Marcellus, in Zone A, associated with Hamilton and Onondaga (Corniferous) species. Two individuals measured 6 mm. and $5\frac{1}{2}$ mm. in length and 6 mm. and $5\frac{1}{2}$ mm. in width, respectively.

A layer of limestone 9 feet above the Onondaga limestone, in the Livonia salt section, contained this same species associated with an even more characteristic Hamilton fauna, but it does not appear in the typical Hamilton faunules.

Genus VITULINA Hall.

61. *Vitulina pustulosa* Hall.

Pal. N. Y., vol. 4, 1867, p. 410, pl. 62.

In the Cayuga Lake section *Vitulina pustulosa* is restricted to the Encrinal beds and Zone D, two rather thin zones over 150 feet apart, and to the Encrinal bed at Eighteenmile Creek. Prof. C. S. Prosser reports it as occurring in Schoharie County in the uppermost portion of the Hamilton,^a and in what is apparently the Lower Hamilton, at Marshall Falls post-office in eastern Pennsylvania.^b

In South America this species occurs throughout, not only what is correlated with the Hamilton, but the entire Devonian. In Bolivia it is reported by Steinmann from the "Conularia Schichten," which he correlated with the Onondaga and Marcellus, and in the Huamapampa sandstone, which is correlated with and includes the Hamilton, the Upper Devonian, and perhaps the Lower Carboniferous. In Brazil it is found in the sandstone of Maecurú and Curuá (Onondaga and Marcellus) and in the Erere sandstone (Hamilton) of Rathbun. In middle Argentina, Kayser found it in the "Kalkig sandig Banke" of "O. von Jachthal" (Onondaga and Marcellus). In South Africa it was collected by Schenk in the Bokkenveld Mountains. At the present writing it has not been reported from Europe.

Two specimens from Zone D, at Cayuga Lake, measured 10 and 8 mm. in width, 8 and 6 mm. in length, and 4 and 3 mm. in thickness. Two specimens from the Encrinal measured 11 by 7 mm. and 11 by 10 mm.

^a Prosser, N. Y. Geol. Sur., 1895.

^b Bull. 120, U. S. G. S., p. 21.

In the Cayuga Lake section this species is confined to two calcareous layers, Zones D and L. At Kashong Creek it occurs in the fine shales underlying the Tully and in the fine black shales overlying the "Basal limestone."

Subfamily ATHYRINÆ Waagen.

Genus ATHYRIS McCoy.

62. *Athyris spiriferoides* Eaton.

Pal. N. Y., vol. 4, 1867, p. 285, pl. 46.

This fossil is very common from the lower part of Zone I, 80 feet below the Encrinal bed, to the top of Zone X. Below this zone it was found in Zone A and in Zone D; elsewhere it is very rare.

Subfamily MERISTELLINÆ Waagen.

Genus MERISTELLA Hall.

63. *Meristella haskinsi* Hall.

Pal. N. Y., vol. 4, 1867, p. 306, pl. 49.

Specimens 22 mm. long and 20 mm. wide were found in the Encrinal bed and in Zone D. A portion of the shell was preserved, showing the wrinkled concentric lines which are crowded in front. On the exfoliated surface the faint radiating lines can be seen. This species has not been reported east of Seneca Lake nor west of Thedford, Canada. It was found only in the Encrinal at Eighteenmile Creek. It occurs in the "Basal limestone" of Slate Rock River (Seneca Lake section).

Order NEOTREMATA Beecher.

Superfamily DISCINACEA Waagen.

Family DISCINIDÆ Gray.

Genus ORBICULOIDEA d'Orbigny.

64. *Orbiculoidea doria* Hall.

(*Discina doria*) Pal. N. Y., vol. 4, 1867, p. 19, pl. 2.

Several specimens were referred to this species with some doubt. The specimens at hand have a more elevated apex and are smaller than is usual in *O. media*. This species is restricted to one zone at Eighteenmile Creek.

65. *Orbiculoidea humilis* Hall.

(*Discina humilis*) Pal. N. Y., vol. 4, 1867, p. 16, pl. 2.

A fragment of a large *Orbiculoidea* from Zone J was referred to this species.

66. *Orbiculoidea lodiensis* Vanuxem.

(*Discina lodensis*) Pal. N. Y., vol. 4, 1867, p. 22, pl. 2.

This species so closely resembles *O. media* that it is difficult to distinguish between them. The faint radiating lines are seen in specimens from Zone T. It is a rare species at Eighteenmile Creek, and is found in but two zones.

67. *Orbiculoidea lodiensis media* Hall.

(*Discina lodensis*) Pal. N. Y., vol. 4, 1867, p. 20, pl. 2.

This is a very common species in the *Orbiculoidea* zone (V). The concretionary layer, in which they are very large, abundant, and well preserved, was traced for a distance of 10 miles. Above and below this zone this fossil is found occasionally, but in no other zone in such abundance.

The *Orbiculoidea media* bed of Grabau, 5 feet above the Encrinural, is the only layer in which it is reported as common at Eighteenmile Creek.

Superfamily CRANIACEA Waagen.

Family CRANIIDÆ King.

Genus CRANIELLA Oehlert.

68. *Craniella hamiltoniæ* Hall.

Pal. N. Y., vol. 4, 1867, p. 27, pl. 3.

This is not an uncommon species in the upper part of Zone Y. Elsewhere in the section it is rarely found. It is a rare fossil at Eighteenmile Creek and Livonia.

Genus PHOLIDOPS Hall.

69. *Pholidops hamiltoniæ* Hall.

Pal. N. Y., vol. 4, 1867, p. 32, pl. 3.

This is a common fossil between Zones X and I, with the exception of the limestone of the Encrinural band. Below Zone I it was not found. The extremes in size are 3 mm. in length and 2 mm. in width for the smallest, and 4 mm. in length and 3 mm. in width for the largest, specimens. The vertical range at Eighteenmile Creek and Livonia is about the same as at the Cayuga Lake section, the center of abundance in those sections being in the upper part of the Lower Hamilton.

70. *Pholidops oblata* Hall.

(*P. oblata* and *linguloides*) Pal. N. Y., vol. 4, 1867, p. 414, pl. 3.

The only specimen of this species, found in Zone L, showed the interior of the ventral (?) valve, but the muscular scars were oblit-

rated. Following Schuchert, *P. linguloides* and *P. oblata* will be considered as the same species. At Eighteenmile Creek it was found in the Encrinal and in a zone 1 foot below. It was not reported from Livonia. Size $4\frac{1}{2}$ mm. wide and $5\frac{1}{2}$ mm. long.

Order PROTREMATA Beecher.

Superfamily STROPHOMENACEA Schuchert.

Family RAFINESQUININÆ Schuchert.

Genus STROPHEODONTA Hall.

71. *Stropheodonta concava* Hall.

Pal. N. Y., vol. 4, 1867, p. 96, pl. 16.

This species is restricted to three narrow zones, X and Y, and S, in the Upper Hamilton. The specimens are well preserved and show the characteristic form and surface markings. Both full-grown and young individuals were collected. The immature specimens do not possess the concavity of the mature individuals, but approach *S. demissa* in form. In both zones where *S. concava* is found, *Streptelasma rectum* is common.

At Eighteenmile Creek this species is rarely found below, and not above, a zone 6 inches thick a foot below the Encrinal. At Livonia it is common in three zones above, and including, the Encrinal, and rarely in two other zones. It is not reported from the Lower Hamilton.

Size 60 mm. in width and 55 mm. in length for the mature, and 40 mm. in width and 30 mm. in length for the immature, forms.

72. *Stropheodonta demissa* Conrad.

Pal. N. Y., vol. 4, 1867, p. 101, pl. 17.

The only specimen of this species was found in Zone I. At Eighteenmile Creek, with few exceptions, it is restricted to 6 inches of shale in the Lower Hamilton within a foot of the Encrinal bed. It is reported as occurring only in the Encrinal at Livonia.

Size 30 mm. in width and 20 mm. in length.

73. *Stropheodonta inæquistriata* Conrad.

Pal. N. Y., vol. 4, 1867, p. 106, pl. 18.

This species is found in the upper 25 feet of the Hamilton, in Zone S, in the Encrinal bed, in Zone I, and, rarely, in Zone D. Between these zones it is rare. Little variation, except in size, is noticeable in the specimens from the different zones.

The width along the cardinal lines of the largest specimen was 40 mm. and the length 28 mm. A smaller specimen measured 13 mm. in width and 10 mm. in length.

At Eighteenmile Creek and Livonia it is common, but has very much the same vertical distribution.

74. *Stropheodonta jania* Hall.

(*Stropheodonta textilis*) Pal. N. Y., vol. 4, 1867, p. 108, pl. 18.

This species is confined to the upper 35 feet of the Upper Hamilton, with the exception of a few specimens in Zone N. The specimens are large and well preserved. It is especially abundant at Lake Ridge in the calcareous shales immediately under the Tully limestone.

At Eighteenmile Creek it is rarely found, in a single zone, a foot below the Encrinal. It is reported as occurring quite commonly in the upper 200 feet of the Upper Hamilton at Livonia, but is not reported from the Lower Hamilton.

75. *Stropheodonta perplana* Conrad.

Pal. N. Y., vol. 4, 1867, p. 98, pls. 11, 12, 17, and 19.

This species is more abundant in this section than *S. inæquistriata* with which it is usually associated. The largest individuals occur in the limestone concretions of the Upper Hamilton. At Eighteenmile Creek it is a common fossil, but is not as abundant as *S. demissa*, a species which is seldom seen in the Cayuga Lake section. *S. perplana* is found throughout the Hamilton of the Livonia section.

76. *Stropheodonta perplana* var.

A single specimen with long, mucronate points, but with the characters of the coarser varieties of *S. perplana*, will not be given a varietal name until more individuals are found. It is possible that the mucronations were due to some disease of the animal. The length of the shell along the hinge line is 42 mm., the width of the body 18 mm., and the length of the shell 14 mm.

Genus PHOLIDOSTROPHIA Hall and Clarke.

77. *Pholidostrophia iowaensis* Owen.

(*Stropheodonta naerea* Hall) Pal. N. Y., vol. 4, 1867, p. 104, pl. 18.

With the exception of the lower part of Zone I, where it is common, this species is very rare in the Cayuga Lake section. It is found rarely in Zones N and Y.

At Eighteenmile Creek it is found in both the Upper and Lower Hamilton. At Livonia it is reported from the Encrinal and from two zones 65 and 90 feet above. At Kashong Creek it occurs both above and below the Encrinal beds, but never in abundance.

Subfamily ORTHOTHETINÆ Waagen.

Genus ORTHOTHETES Fischer de Waldheim.

78. *Orthothetes chemungensis* var. *arctostriatus* Hall.

(*Streptorhynchus chemungensis arctostriata*) Pal. N. Y., vol. 4, 1867, p. 71, pl. 9.

This variety, though seldom common, is found in almost every zone in the Upper Hamilton, and is not uncommon, with the exception of

Zone E, in the Lower Hamilton above Zone D. It is quite constant in its form and surface markings. At Eighteenmile Creek it is scattered throughout the section from the lowest to the highest zone. It is rare above the Encrinal, but common in several zones below. At Livonia it is commoner above than below the Encrinal beds.

79. *Orthothetes chemungensis* var. *perversus* Hall.

(*Streptorhynchus chemungensis perversus*) Pal. N. Y., vol. 4, 1867, p. 72, pl. 9.

This fossil was not found above and rarely below the Encrinal beds at Cayuga Lake. This variety is readily distinguished from *O. chemungensis arctistriatus* by its larger form and surface markings. It is rare at Eighteenmile Creek, where it is found only below the Encrinal.

80. *Orthothetes chemungensis* var.

A variety of *Orthothetes* approaching Hall's type, *Streptorhynchus pectinacea*, was found in Zone A. All of the specimens are casts, or show only the interior of the shell. One very good specimen measures about 10 mm. in length, 15 mm. in width, and the cardinal area 2 mm. high. In this specimen there are seventeen prominent striae, with from two to no weak striae between. The surface is marked by very fine undulating concentric lines.

Family PRODUCTIDÆ Gray.

Subfamily CHONETINÆ Waagen.

Genus CHONETES Fischer de Waldheim.

81. *Chonetes coronatus* Conrad.

Pal. N. Y., vol. 4, 1867, p. 133, pl. 21.

A single specimen of dorsal valve of this species was found in Zone A, associated with Onondaga (Corniferous) species. With the exception of this zone and Zone D, it was not found below Zone II. Between Zone H and T it has its greatest abundance. In the upper 10 feet of the Upper Hamilton it is extremely rare.

At Livonia it is reported from the Encrinal and above, but was not found in the Lower Hamilton. With the exception of the Encrinal and a foot of shale immediately below, this species is rare at Eighteenmile Creek.

82. *Chonetes lepidus* Hall.

Pal. N. Y., vol. 4, 1867, p. 132, pl. 21.

This species is sometimes not easily distinguished from the young individuals of other species of *Chonetes*. Specimens from Zones X and Y possess a number of points of differences from the typical *C. lepidus*, but may be of this species. On page 133 of vol. 4, Pal. N. Y., Hall says that the original specimens designated as *C. lepidus*

are very small, almost hemispheric shells. The striæ are very strong, angular, etc. This description accords fairly well with the specimens in question.

At Eighteenmile Creek *C. lepidus* is the most common species of *Chonetes* in the Hamilton shale. "It is everywhere abundant, in some layers extremely so."^a This species is not so common at Cayuga Lake as either *C. scitulus*, *C. mucronatus*, or *C. vicinus*. It is found in all the zones of the Upper Hamilton with the exception of the Encrinal bed. In the Lower Hamilton it is not common in any zone and is entirely wanting in the lower half of Zone C.

83. *Chonetes lineatus* Conrad.

Pal. N. Y., vol. 4, 1867, p. 121, pl. 20.

This Onondaga (Corniferous) species was found in Zone A, where it is very common. It was associated with *Anoplothea camilla*, *S. macrus*, *Chonetes coronatus*, *C. mucronatus*, and *Ambocelia umbonata*.

84. *Chonetes mucronatus* Hall.

Pal. N. Y., vol. 4, 1867, p. 124, pls. 20 and 21.

This species is very common in the lowest zone in the section, Zone A. It is met with rarely in Zone C, and is common in the first *Terebratula* zone. Above this to the Encrinal its place is taken by *Chonetes vicinus*. In the Upper Hamilton it is a very common and well-preserved fossil. *C. mucronatus* is not common at Eighteenmile Creek, "where it is nearly restricted to the lower-Moscow shales." At Livonia it is not reported from the Upper Hamilton, but is found in the Lower Hamilton.

85. *Chonetes scitulus* Hall.

Pal. N. Y., vol. 4, 1867, p. 130, pl. 21.

This species comes next to *C. mucronatus* in abundance in this section. It is rarely found in the first and second *Leiorhynchus* zones, but is common especially in the lower half of the Upper Hamilton.

At Livonia it is common throughout the Upper and Lower Hamilton, while at Eighteenmile Creek it is common in the Lower but rare in the Upper Hamilton.

86. *Chonetes setigerus* Hall.

Pal. N. Y., vol. 4, 1867, p. 130, pl. 21.

A single specimen of this species was found in Zone T.

87. *Chonetes vicinus* Castelnau.

(*C. deflecta*, Hall), Pal. N. Y., vol. 4, 1867, p. 128, pl. 21.

King Ferry station is one of the type localities for this species. As developed here it is distinguished from *C. mucronatus* by its larger

^aTenth Annual Rept. State Geol. N. Y., 1896.

size and greater number and fineness of the striae. The average size is 7 mm. in length and 13 mm. in width. It is an exceptionally abundant species in the first 115 feet below the Encrinal. It was not found above or below this zone.

At Eighteenmile Creek it is common in one zone 2 or 3 feet above the Encrinal, but is rare in the Lower Hamilton. At Livonia it is found throughout the section, with the exception of the upper 160 feet of the Upper Hamilton.

87a. *Chonetes* sp.

A specimen which could not be referred to any described species of *Chonetes* was found in Zone I. The size is 4 mm. in length and 7 mm. in width. The striae are fine and round and number 32. The spaces between the striae have a reticulate appearance.

Subfamily PRODUCTINÆ Waagen.

Genus PRODUCTELLA Hall.

88. *Productella spinulicosta* Hall.

Pal. N. Y., vol. 4, 1867, p. 160, pl. 23.

This is a widespread but not an abundant species in this section, being found in almost every zone from Zone D to the Tully limestone. It was found in the arenaceous shales of the Marcellus, but is wanting in the fine shales of Zone C, its place being taken by *Strophalosia truncata*. A specimen from Zone Y bears a strong resemblance to *P. lachrymosa* (Conrad) of the Chemung and may be of that species. *P. spinulicosta* is an extremely variable species.

89. *Productella navicella* Hall.

Pal. N. Y., vol. 4, 1867, p. 156, pl. 23.

A few specimens from concretionary layers in the upper part of Zone C, about 65 feet below Zone D, in Dean Creek, were referred provisionally to this species. The arcuate form, small size, and the position of the spines accord well with the description given by Hall.

Genus STROPHALOSIA King.

90. *Strophalosia truncata* Hall.

(*Productella truncata*) Pal. N. Y., vol. 4, 1867, p. 160, pl. 23.

This species was found in the Marcellus shales and continued up into the barren shales of Zone E. In one layer in Zone C, a fraction of an inch thick, it occurs in great abundance. At Eighteenmile Creek it is found in the Marcellus shales and rarely in the next zone above.

Family ORTHIDÆ Woodward.

Genus RHIPIDOMELLA Oehlert.

91. *Rhipidomella vanuxemi* Hall.

(*Orthis vanuxemi*) Pal. N. Y., vol. 4, 1867, pp. 40, 47, pl. 5.

This is a very common species in the Upper Hamilton in the Cayuga Lake section, but was found in only one zone in the Lower Hamilton. It has the same range at Livonia as at Cayuga Lake, except that it is not reported from the shales below the Encrinal.

At Eighteenmile Creek it is one of the commonest fossils in the Lower Hamilton and is found rarely, and in but one zone, above the Encrinal.

At Cayuga Lake, with the exception mentioned above, no rhipidomellas are found in the Lower Hamilton. This is true of the Livonia section with the exception of *R. lenticularis* (?), which is reported as common in a mixed Onondaga (Corniferous) and Hamilton faunule at the base of the Lower Hamilton.

92. *Rhipidomella cyclos* Hall.

Pal. N. Y., vol. 4, 1867, p. 52, pl. 7.

One specimen from Zone T was identified as this species. The striae are sharper and fewer and the hinge line longer than in the small forms of *R. vanuxemi*.

93. *Rhipidomella penelope* Hall.

Pal. N. Y., vol. 4, 1867, p. 50, pl. 6.

One specimen from Zone Y is referred to this species because of its larger size. The surface markings were obliterated. It may prove to be a large individual of *R. vanuxemi*.

This species is common at Kashong and Eighteenmile creeks.

Superfamily PENTAMERACEA Schuchert.

Family PENTAMERIDÆ McCoy.

Genus PENTAMERELLA Hall.

93a. *Pentamerella pavilionensis* Hall.

Pal. N. Y., vol. 4, 1867, p. 377, pl. 58.

A few badly crushed specimens of this species were found in the lower portion of Zone D. It is not uncommon in the Encrinal beds of the Seneca Lake section.

Subkingdom MOLLUSCA.

Class PELECYPODA Goldfuss.

The Pelecypoda in this paper are classified according to Dall, as given in Eastman's translation of Zittel's "Text Book of Palæontology," 1900. Genera which are not mentioned in the text-book are placed with the most closely allied forms. Such additions are indicated by a question mark before each genus so referred.

Adjustment to environment.—The Pelecypoda of the Hamilton seemed to be very much less closely adjusted to their environment than the Brachiopoda, as is shown by the fact that an apparently slight change of environment was sufficient to produce a great abundance or almost total extinction of certain genera of Brachiopoda, whereas the Pelecypoda often survived several changes of these brachiopod faunules and were never abundant.

Order PRIONODESMACEA Dall.

Family SOLEMYACIDÆ Dall.

Genus PHTHONIA Hall.

94. *Phthonia nodicostata* Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 474, pl. 78.

Two specimens of this species were found in Zone M. They measured 23 and 20 mm. in length.

95. *Phthonia cylindrica* Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 473, pl. 78.

A single individual of this species was found in each of three zones. Two of these measured 17 and 21 mm. in length, and 8 and 10 mm. in height, respectively.

96. *Phthonia sectifrons* Conrad.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 475, pl. 78.

A right valve of this species, with the surface markings well preserved, was found in Zone Y.

Family SOLENOPSIDÆ Neumayr.

Genus ORTHONOTA Conrad.

97. *Orthonota carinata* Conrad.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 479, pl. 78.

This well-marked species was found rarely in two zones in the Upper and two in the Lower Hamilton.

98. *Orthonota undulata* Conrad.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 478, pl. 78.

This species was found in both the Upper and Lower Hamilton. Five specimens measured 64, 62, 57, 40, and 27 mm. in length and 16, 15, 15, 10, and 8 mm. in height, respectively.

99. *Orthonota* (?) *parvula* Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 482, pls. 65, 78.

This species is rare in every part of the section, but is found in a number of zones in both the Upper and Lower Hamilton above Zone D. At Livonia it was found in the upper 160 feet of the Hamilton and in one other zone above the Eneinal.

Genus *PROTHYRIS* Meek.100. *Prothyris lanceolata* Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 460, pl. 76.

This is a very rare species in this section. The largest specimen measured 25 mm. in length and 10 mm. in height, the smallest about 10 mm. in length and 2½ mm. in height.

101. *Prothyris truncata* sp. nov.

Shell small, rectangulate, length more than twice the height. Basal margin nearly straight and truncate behind, cardinal line long, straight, essentially parallel to the basal margin. Anterior end limited from the body by a low, narrow fold. Valves almost flat. Beaks very inconspicuous. A well-marked diagonal ridge is situated slightly posterior to the beak. Shell marked by faint concentric striae, which are somewhat fasciculate along the basal margin.

Three specimens measured 13, 11, and 10 mm. in length, and 5, 3, and 3 mm., respectively, in height.

This species differs from *P. lanceolata* in its truncated posterior extremity and in the diagonal ridge; from *P. planulata* in the flatness of the valves and the absence of an angular umbonal slope.

Family GRAMMYSIIDÆ Fischer.

Genus *GRAMMYSIA* de Verneuil.102. *Grammysia constricta* Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 377, pls. 59 and 78.

This species is rare throughout the section, and was not found below Zone D. The surface markings vary from almost continuous radiating lines to widely separated pustules, which can hardly be said to present a radiating appearance.

103. *Grammysia cuneata* Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 383, pls. 62 and 93.

This species, like all species of *Grammysia*, is far from common in any portion of the section.

104. *Grammysia arcuata* Conrad.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 373, pls. 61, 63, and 93.

Ten or 15 feet below the Encrinal this species is quite common, elsewhere it is rare. Three valves (one of which measures fully 80 mm. in length) from Zone Y answer the description of *G. subarcuata* of the Chemung fairly well, but were included in *G. arcuata*.

105. *Grammysia bisulcata* Conrad.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 359, pls. 56 and 93.

A few specimens of this species were found in Zone G. It is reported from the upper 160 feet of the Upper Hamilton at Livonia.

Genus ELYMELLA Hall.

106. *Elymella fabalis* Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 502, pl. 40.

Two valves from Zone Y are referred to this species. The anterior end is rather too long for *E. fabalis*, but may be a variation.

107. *Elymella nuculoides* Hall.

Pal. N. Y., vol. 5, pt. 1, p. 503, pl. 40.

A few specimens of this species were found in Zone X.

Genus GLOSSITES Hall.

108. *Glossites subtenuis* Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 495, pl. 40.

There is some doubt as to the correctness of the identification of the specimen referred to this species.

Genus TELLINOPSIS Hall.

109. *Tellinopsis submarginata* Conrad.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 464, pl. 76.

This species is common in Zone X, the center of Zone T, Zone J, Zone G, and the lower portion of Zone D. It is never abundant and seldom common, but is found in almost all the zones in this section.

At Eighteenmile Creek a single specimen was found. It is reported from four zones in the Upper Hamilton of the Livonia section.

Two large specimens were 45 and 30 mm. long and 27 and 17 mm. wide.

Family CARDIOLIDÆ Neumayr.

Genus PANENKA Barrande.

110. *Panenka lincklæni* Miller.

Pal. N. Y., vol. 5, pt. 1, p. 420, pl. 69.

The specimen which was referred to this species is probably a new species. It differs from *P. lincklæni* in the broad concave plications, the almost flat interspaces, and the absence of intermediate radii. Both plications and interspaces are crossed by fine concentric lines. Found in Zone T.

111. *Panenka potens* Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 422, pl. 69.

A very imperfect specimen about 60 mm. in height is doubtfully referred to this species. It was found associated with *Lunulicardium curtum* and *L. ornata* in Zone C.

112. *Panenka* sp. undet.

A small, well-preserved cast of a *Panenka* from Zone X does not answer the description given in the New York Paleontology. It is about 12 mm. high and of the same length. The plications number 22 and reach the beak. Faint concentric lines can be seen. This specimen bears a resemblance to *P. retusa*, which is reported from Cayuga Lake. The plications of *P. retusa*, however, number 35, with narrow interspaces, while the size is 30 mm. in length and 31 mm. in height.

Genus GLYPTOCARDIA Hall.

113. *Glyptocardia speciosa* Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 426, pls. 70 and 80.

This species is found occasionally in Zones T, F, and E; elsewhere in the section it is very rare or wanting. The largest specimen from Zone F measured 11 mm. in height. It is not reported from Eighteen-mile Creek or Livonia.

Superfamily NUCULACEA.

Family (?) CTENODONTIDÆ Dall.

Genus NUCULITES Conrad.

114. *Nuculites triqueter* Conrad.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 326, pls. 47 and 93.

This species is common throughout the section, except where the shales are calcareous, as in the Encrinal bed, Zone D and Zone G. The variations in form are not progressive. It is not uncommon at Livonia, but was not found above the Marcellus shale at Eighteen-mile Creek.

115. *Nuculites oblongatus* Conrad.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 324, pl. 47.

What has been said regarding the distribution of *N. triqueter* in the Cayuga Lake section is true of *N. oblongatus*. The conditions which were favorable to one were favorable to the other.

At Eighteenmile Creek it is rare in the only zone in which it occurs.

Family NUCULIDÆ Adams.

Genus NUCULA Lamarck.

116. *Nucula varicosa* Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 319, pls. 46 and 93.

This is a very variable species, the extremes of which are often difficult to classify. It is one of the rarer nuculas.

117. *Nucula randalli* Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 315, pls. 45 and 93.

A small *Nucula* from Zone I was referred doubtfully to this species.

118. *Nucula lirata* Conrad.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 316, pls. 45 and 93.

This is a common species in the Upper but is not often found in the Lower Hamilton in this section. It is reported from two zones in the Upper Hamilton at Livonia. It does not occur at Eighteenmile Creek.

119. *Nucula bellistriata* Conrad.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 318, pl. 46.

This species is so closely related to *N. varicosa* that in some cases it is difficult to distinguish between them. It is not uncommon between Zone D and the Tully limestone, but is never abundant.

120. *Nucula corbuliformis* Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 319, pl. 46.

This is more common and has a greater vertical distribution than any other *Nucula* in the section. It is found throughout the Marcellus and Hamilton shales along Cayuga Lake. Unlike the Brachiopoda, it is present in almost every zone except those which are very calcareous, as the Enderinal, and, although it is never exceptionally abundant in the aggregate, the number of individuals is very great.

Family LEDIDÆ Adams.

Genus LEDA Schumacher.

121. *Leda rostellata* Conrad.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 330, pl. 47.

This species is common in the *Stropheodonta*-Coralline zone, but is rare elsewhere in the section. It was not found in the Marcellus shales or Zone C. It is not reported from Livonia or Eighteenmile Creek.

122. *Leda brevirostris* Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 329, pl. 47.

Specimens from Zone Y were referred to this species.

Genus PALÆONEILO Hall.

123. *Palæoneilo constricta* Conrad.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 333, pls. 48 and 51.

P. constricta is a common and sometimes an almost abundant species throughout the greater portion of the section above Zone D. It was also found in the upper part of Zone C. Its greatest abundance is in Zone T.

124. *Palæoneilo emarginata* Conrad.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 338, pl. 50.

This strongly marked species is common in Zone W, in the lower part of Zone T, and in Zone I; elsewhere in the section it is very rare.

125. *Palæoneilo plana* Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 334, pl. 48.

This species was not found below Zone R. It is quite common in Zone W and in the upper part of Zone T.

126. *Palæoneilo maxima* Conrad.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 335, pl. 48.

A single specimen from Zone Y was referred to this species. It measured 34 mm. in length by 19 mm. in height.

127. *Palæoneilo muta* Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 337, pl. 49.

This species was found only in the Upper Hamilton, and then but rarely. Three specimens measured 19, 16, and 10 mm. in length and 11, 8, and 5 mm. in height, respectively.

128. *Palaeoneilo fecunda* Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 336, pl. 49.

This is a rare species in this section. With the exception of a single specimen from Zone I, it is only found, and rarely, in the Upper Hamilton.

129. *Palaeoneilo tenuistriata* Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 336, pls. 49 and 93.

This species is restricted to a narrow zone in the Upper Hamilton of which Zone W is the center. One specimen, which retains a portion of the shell, shows radiating lines apparently due to the original color of the shell. Other specimens show faint radiating lines.

Family PARALLELODONTIDÆ Dall.

Genus PARALLELODON Meek.

130. *Parallelodon hamiltoniæ* Hall.

(*Macrodon hamiltoniæ*) Pal. N. Y., vol. 5, pt. 1, 1885, p. 349, pl. 51.

This species is quite common from Zone D to the Tully limestone. It was found in Zones B and C.

(?) Genus SPHENOTUS Hall.

131. *Sphenotus arcæformis* Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 395, pls. 65 and 66.

A small specimen of this species from Zone K measured 9 mm. in length and 4 mm. in height. The normal size is 26 to 32 mm. in length and 12 to 14 mm. in height.

132. *Sphenotus cuneatus* Conrad.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 396, pl. 65.

Four well-marked specimens of this species were found in Zone G. The specimens measured 19, 15, 16, and 6 mm. in length and 9, 8, 8, and 4 mm., respectively, in height.

133. *Sphenotus solenoides* Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 398, pl. 45.

This is a rare species in this section. It was found in Zones D and L.

Superfamily PTERIACEA Dall.

Family PTERINEIDÆ Dall.

Genus PTERINEA Goldfuss.

134. *Pterinea flabella* Conrad.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 93, pls. 14 and 15.

This species was not found in the Upper Hamilton and is very rare in the Lower Hamilton, being common in no zone. At Eighteenmile Creek it is found commonly a few feet below the Encrinal beds, but is not reported above.

Family LUNULICARDIIDÆ Fischer.

Genus LUNULICARDIUM Münster.

135. *Lunulicardium fragile* Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 434, pl. 71.

This species, with the exception of Zone D, is not uncommon between Zones A and G. Above Zone G it is rarely found. At Eighteenmile Creek it is reported from but one zone above the Marcellus shale. At Livonia it is a common fossil below the Encrinal, and is abundant in one zone of the Upper Hamilton.

136. *Lunulicardium curtum* Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 437, pl. 71.

This occurs rarely in the shales of Zone C and the Marcellus.

137. *Lunulicardium ornatum* Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 437, pl. 71.

This species was found in the upper part of Zone C.

Family AMBONYCHIIDÆ Miller.

Genus PLETHOMYTIUS Hall.

138. *Plethomytilus oviformis* Conrad.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 255, pls. 81 and 87.

This species was found in Zones I, F, X, and Y. The specimens measured 62, 32, and 8 mm. in height, and 50, 26, and 6 mm. in length. At Eighteenmile Creek it is restricted to the upper Encrinal beds.

Genus MYTILARCA Hall.

139. *Mytilarca gibbosa* Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 262, pls. 88 and 87.

The specimen which was referred provisionally to this species is about midway between *M. gibbosa* and *M. simplex* in form. It measures 35 mm. in height and 24 mm. in length.

Genus SPATHELLA Hall.

140. *Spathella typica* Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 407, pl. 66.

This specimen is 28 mm. in length and 14 or 15 mm. in height. It is slightly crushed dorso-ventrally. The concentric lines are strong, with occasional finer concentric striæ between,

Family CONOCARDIIDÆ Neumayr.

Genus CONOCARDIUM Bronn.

141. *Conocardium normale* Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 411, pl. 68.

A single specimen of this genus was found in Zone I. The surface markings on the posterior and the anterior expansion of the shell along the edge of the umbonal ridge can be made out.

Family PTERIIDÆ Meek.

Subgenus ACTINOPTERIA Hall.

142. *Actinopteria boydi* Conrad.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 113, pls. 19 and 84.

This is a rare fossil in this section. It is found occasionally in the limy shales of Zones Y and D.

143. *Actinopteria decussata* Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 111, pls. 17, 18, 20, and 84.

A few specimens of this species were found in the Upper Hamilton.

144. *Actinopteria subdecussata* Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 110, pls. 17 and 19.

A single specimen was found in Zone T.

Genus LEIOPTERIA Hall.

145. *Leiopteria greeni* Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 160, pls. 20 and 88.

A single specimen of this species was found in Zone L. It measured 38 mm. in height and 32 mm. along the hinge line.

146. *Leiopteria lævis* Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 158, pls. 17 and 20.

This species is common in the Upper Marcellus, seldom found in Zone C, and occasionally in the shales above Zone D.

147. *Leiopteria rafinesquii* Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 161, pls. 15, 20.

Specimens from Zones J and D belong to this species.

148. *Leiopteria gabbi* Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 169, pl. 88.

One individual of this species was found in Zone C. One from Zone T was referred to it with some doubt.

149. *Leiopteria sayi* Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 162, pl. 88.

This species is rather common in Zone T, but not elsewhere in the section. It is associated with *L. lævis*.

150. *Leiopteria conradi* Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 159, pls. 20 and 88.

A number of specimens from Zones D and T were of this species. A number of intermediate forms were included.

151. *Leiopteria dekayi* Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 164, pls. 19, 20, 88.

One specimen from Zone T was of this species. It was not perfect, but the obliqueness of the form, which is very characteristic of *L. dekayi*, is quite pronounced.

Family MYALINIDÆ Frech.

Genus MODIELLA Hall.

152. *Modiella pygmaea* Conrad.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 514, pl. 76.

This species is found occasionally in Zone C and is one of the common fossils from Zone D to within a foot of the Tully limestone. It reaches its greatest abundance in Zone T. It has very much the same habit as *Nuculites oblongatus* and *N. triquetus*. Although seldom common, it is almost always present except in very limy sediments.

Superfamily TRIGONIACEA Bronn.

Family TRIGONIIDÆ Lamarek.

Genus SCHIZODUS King.

153. *Schizodus appressus* Conrad.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 449, pl. 75.

This is a rare species, but is not confined to any one zone.

154. *Schizodus contractus* Hall.

Pal. N. Y., vol. 5, pt. 1, p. 451, pl. 75.

Specimens of this species were found in the shales immediately under the Tully limestone and in Zone D. Between these zones it is wanting. One individual measured 4 mm. in height and 7 mm. in length.

Superfamily PECTINACEA Reeve.**Family PECTINIDÆ Lamarek.****Genus AVICULOPECTEN McCoy.****155. *Aviculopecten princeps* Conrad.**

Pal. N. Y., vol. 5, pt. 1, 1885, p. 1, pls. 1, 5, 6, 24, and 81.

This species is from the upper and lower portions of the Upper Hamilton. It seemed to thrive best in calcareous sediments. One right valve had markings similar to those shown in pl. 81, fig. 16. It was found in six zones at Eighteenmile Creek.

156. *Aviculopecten fasciculatus* Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 11, pls. 5 and 81.

One imperfect specimen from Zone D was doubtfully referred to this species.

157. *Aviculopecten scabridus* Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 7, pl. 3.

A very much distorted specimen with the characteristic surface markings was found in Zone G.

Subgenus *Pterineopecten* Hall.**158. *Pterineopecten undosus* Hall.**

Pal. N. Y., vol. 5, pt. 1, 1885, p. 72, pls. 2 and 82.

This species is restricted to the Upper Hamilton and the upper 50 feet of the Lower Hamilton. It is nowhere common, and varies greatly in shape and surface markings.

159. *Pterineopecten vertumnus* Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 71, pls. 5 and 83.

This species is found in three zones, only one specimen being found in each.

*** 160 *Pterineopecten intermedius* Hall.**

Pal. N. Y., vol. 5, pt. 1, 1885, p. 68, pls. 17 and 83.

This species is slightly commoner than the preceding species of *Pterineopecten*, and is found in a number of zones from Zone D to the Tully.

161. *Pterineopecten hermes* Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 64, pl. 17.

This is a well-marked but variable species, and when poorly preserved often resembles *P. intermedius*.

Subgenus *LYRIOPECTEN* Hall.162. *Lyriopecten orbiculatus* Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 42, pls. 4 and 82.

A specimen from Zone D was referred with considerable certainty to this genus and species.

Superfamily MYTILACEA Ferussac.

Family MODIOLOPSIDÆ Fischer.

Genus MODIOMORPHA Hall.

163. *Modiomorpha subalata* Conrad.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 283, pls. 35 and 39.

This species is not uncommon in Zones J, F, and the upper part of C. Four specimens measured, respectively, 19, 21, 24, and 32 mm. in length and 11, 12, 15, and 18 mm. in height. It is a common species in the Lower Hamilton at Eighteenmile Creek.

164. *Modiomorpha concentrica* Conrad.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 275, pls. 34, 35, 36.

This is the commonest *Modiomorpha* at Cayuga Lake. It is distributed from Zone D to the uttermost zone in the Hamilton. It is common in Zones H, O, T, and X. At Eighteenmile Creek it is common in the Encrinal and is found occasionally in the Lower, but does not occur in the Upper Hamilton.

165. *Modiomorpha mytiloides* Conrad.

Pal. N. Y., vol. 5, pt. 1, p. 277, pls. 37 and 38.

This species is far from being common, but is found occasionally in Zone D and above. It is common in three zones above the Encrinal at Livonia, but it is not reported from Eighteenmile Creek.

166. *Modiomorpha alta* Conrad.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 278, pls. 37, 80.

Two small specimens from Zone X were referred to this species. A number of specimens which seem to be of a new species have been placed in this species. The measurements of these were 25, 18, 15, 10, and 4 mm. in length and 16, 11, 11, 7, and 5 mm. in height.

Genus GONIOPHORA Phillips.

167. *Goniophora hamiltonensis* Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 296, pl. 43.

This species is found rarely in eight zones, commencing with the first *Terebratula* zone (D), to the Tully limestone.

168. *Goniophora truncata* Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 298, pls. 42 and 44.

This well-marked species was found in Zones S and Y. Only one specimen was found in each zone and both were badly crushed.

169. *Goniophora rugosa* Conrad.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 297, pls. 42 and 43.

A few specimens of this species were found between Zone D and the Tully limestone. Two specimens measured 40 and 45 mm. in length and 26 and 28 mm. in height, respectively.

170. *Goniophora glaucus* Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 299, pls. 43 and 44.

A single badly crushed specimen from Zone Y was referred to this species with doubt.

Order ANOMALODESMACEA Dall.**Superfamily ANATINACEA Dall.****Family PHOLADELLIDÆ Miller.****Genus PHOLADELLA Hall.****171. *Pholadella radiata* Conrad.**

Pal. N. Y., vol. 5, pt. 1, 1885, p. 469, pls. 78 and 96.

This species was not found in the Marcellus shales nor in Zone C, but is scattered throughout the remainder of the section. It occurs frequently in the upper shales of the Lower Hamilton and is almost abundant in Zone O.

Three specimens measured 25, 7 and 5 mm. in length and 13, 4, and 2 mm. in height, respectively.

172. *Pholadella parallela* Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 470, pl. 78.

This well-marked species was found in Zone T. It is rare in this zone and was not obtained elsewhere in the section.

Genus CIMITARIA Hall.**173. *Cimitaria corrugata* Conrad.**

Pal. N. Y., vol. 5, pt. 1, 1885, p. 465, pl. 77.

This species was found in Zones Y and H, but was not seen elsewhere in the section.

174. *Cimitaria elongata* Conrad.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 466, pl. 77.

Two specimens of this species were obtained from the Eocerinal band at King Ferry.

Order TELEODESMACEA Dall.

Superfamily CYPRICARDIACEA Dall.

Family PLEUROPHORIDÆ Dall.

Genus CYPRICARDELLA Hall.

175. *Cypricardella bellistriata* Conrad.

(*Microdon bellistriatus*) Pal. N. Y., vol. 5, pt. 1, 1885, p. 308, pls. 42, 73, 74.

This species is common in the upper part of the Upper Hamilton and in the upper portion of the Lower Hamilton; in the latter it is almost abundant. Aside from these two zones the species is quite rare in this section.

At Eighteenmile Creek it was not found above the Eocerinal and, with the exception of one zone at the base of the Hamilton, is very rare throughout the section. One very large specimen from the Eocerinal bed on Paines Creek measured 60 mm. in length and 38 mm. in height.

Genus CYPRICARDINIA Hall.

176. *Cypricardinia indenta* Conrad.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 485, pls. 79 and 96.

This species is common in two zones, in Zone X and the middle third of Zone D.

Specimens measured 14, 9, and 7 mm. in length and 8, 5, and 4 mm. in height, respectively. It is a Lower Hamilton fossil at Eighteenmile Creek.

Superfamily LUCINACEA Anton.

Family LUCINIDÆ Fleming.

Genus PARACYCLAS Hall.

177. *Paracyclas tenuis* Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 443, pls. 72 and 95.

This species is rather common in three zones of the Upper and in one zone of the upper part of the Lower Hamilton. It varies greatly in size and in the strength of its concentric striæ, but is readily distinguished from the other species of this genus. It is not reported from Eighteenmile Creek or Livonia.

178. *Paracyclas lirata* Conrad.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 441, pls. 72 and 95.

Only two small valves of this species were found. They measured about $7\frac{1}{2}$ mm. in height by 8 mm. in length.

Class GASTEROPODA.

The Gasteropoda were not found to be of much value in this faunal study. They are never common, but are found occasionally in almost all of the zones.

Subclass STREPTONEURA Spengel.**Order ASPIDOBANCHIA Schweigger.****Suborder RHIPIDOGLOSSA Troschel.****Family PLEUROTOMARIIDÆ d'Orbigny.****Genus PLEUROTOMARIA de France.****179. *Pleurotomaria itys* Hall.**

Pal. N. Y., vol. 5, pt. 2, 1879, p. 76, pl. 20.

As with the other species of the genus, *P. itys* is not common in nor characteristic of any zone. It occurs throughout the section. At Eighteenmile Creek it is found only at the base of the Hamilton.

180. *Pleurotomaria capillaria* Conrad.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 77, pl. 20.

It is often difficult to distinguish the extremes of this species from the above unless the specimens are well preserved. Quite generally distributed throughout the section. Confined to the base of the Hamilton at Eighteenmile Creek.

181. *Pleurotomaria trilix* Hall.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 79, pl. 21.

Found rarely in the Upper Hamilton at Cayuga Lake.

182. *Pleurotomaria sulcomarginata* Conrad.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 69, pl. 19.

Two specimens of this species were obtained from the upper part of the Upper Hamilton, Zones W and T.

183. *Pleurotomaria rotalia* Hall.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 71, pl. 19.

Two specimens from Zone T were of this species.

184. *Pleurotomaria rugulata* Hall.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 75, pl. 20.

This species is met with occasionally in Zone C, in the Marcellus shales, and in Zone D. The specimens are all very much crushed or in the form of molds, and the surface markings are indistinct.

Family BELLEROPHONTIDÆ McCoy.

Genus BELLEROPHON de Montfort.

185. *Bellerophon patulus* Hall.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 100, pls. 22 and 24.

This species is not uncommon in Zones X and N; elsewhere it is rare. It was not found below Zone C. The specimens obtained were of the usual size, but badly crushed.

186. *Bellerophon leda* Hall.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 110, pl. 23.

This is the most common *Bellerophon* in the section. It is almost common in some of the thin layers of Zone C. It is common in the lower portion of the Lower Hamilton at Eighteenmile Creek.

187. *Bellerophon lyra*.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 113, pl. 23.

Only a few specimens of this species were found in the section.

188. *Bellerophon crenistria* Hall.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 116, pl. 25.

A few specimens of this species were obtained in six zones of the Upper and Lower Hamilton.

Genus CYRTOLITES Conrad.

189. *Cyrtolites mitella* Hall.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 123, pl. 25.

Only a few specimens of this species were obtained. None were found lower than Zone D.

Family EUOMPHALIDÆ de Koninek.

Genus EUOMPHALUS Sowerby.

190. *Euomphalus* sp.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 54.

A single crushed specimen from Zone O was referred to this genus. The specific characters could not be made out.

Order CTENOBRANCHIATA Schweigger.

Suborder PLATYPODA.

Superfamily TÆNIOGLOSSA Bouvier.

Family CAPULIDÆ Cuvier.

Genus PLATYCERAS Conrad.

191. *Platyceras conicum* Hall.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 3, pl. 1.

A single large specimen was found in the Encrinal beds.

192. *Platyceras erectum* Hall

Pal. N. Y., vol. 5, pt. 2, 1879, p. 5, pl. 2.

This gastropod was found most commonly in the upper portion of the Encrinal and in the limestone of Zone Y. Elsewhere it is rare.

193. *Platyceras bucculentum* Hall.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 10, pl. 3.

Typical specimens of this species were found in Zones Y and S.

194. *Platyceras carinatum* Hall.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 5, pl. 2.

Specimens having the characteristic shape of this species were found in Zones W and Y.

Genus PLATYOSTOMA Conrad.

195. *Platyostoma lineata* Conrad.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 21, pl. 10.

This species was found in a number of zones, but was not common in any. It possesses, in all cases, the characteristic surface markings.

196. *Platyostoma varians* Hall.

(*Strophostylus*) Pal. N. Y., vol. 5, pt. 2, 1879, p. 31, pl. 11.

A large specimen from Zone J and eight smaller ones from Zone C were referred to this species with some doubt. The larger specimen is typical; the smaller ones are small, and may be of a new species.

Superfamily GYMNOGLOSSA.

Family PYRAMIDELLIDÆ Gray.

Genus LOXONEMA Phillips.

197. *Loxonema hamiltoniæ* Hall.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 45, pl. 13.

This species occurs throughout the entire section. It is often difficult to distinguish it from *L. delphicola* when the specimens are imperfect. At Eighteenmile Creek this species and *L. delphicola* are restricted to the Upper Marcellus shales.

198. *Loxonema delphicola* Hall.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 47, pls. 13 and 14.

This species is frequently met with in the section above Zone D. It is commoner than *L. hamiltoniae*. Very often the shell is surrounded by a "smooth, polished shale (slickensides)," as is figured by Hall in figs. 24 and 25 of the above report.

Superfamily PTENOGLOSSA Gray.

• Family SCALARIIDÆ Broderip.

Genus CALLONEMA Hall.

199. *Callonema imitator* Hall and Whitfield.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 53, pl. 14.

One specimen, 50 mm. in diameter, with the surface marked by strong elevated striae gently curving backward and increasing in strength from the apex to the last volution, was found in Zone N. The coil is rather loose.

Order OPISTHOBRANCHIA Milne-Edwards.

Suborder PTEROPODA Cuvier.

Family CAVOLIINDÆ Fischer.

Subgenus STYLIOLA Lesueur.

200. *Styliola fissurella* Hall.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 178, pl. 31A.

It will be noticed in the table of species that *S. fissurella* is very rare, almost wanting, in the Upper Hamilton; that between Zone D and the Encrinal, with the exception of the fine shales of Zone E, it is also very rare, and that in the fine shales of Zone C and in the Marcellus shales it is very common. In the lower portion of the Marcellus shales the *Styliola* is beautifully preserved in pyrite. It is very abundant in certain layers in the Marcellus shales. At Eighteenmile Creek it is very common in a number of zones of the Lower and is fairly common in the uppermost zone of the Upper Hamilton.

Suborder CONULARIDA Miller and Gurley.

Family TENTACULITIDÆ Walcott.

Genus TENTACULITES Schlotheim.

201. *Tentaculites bellulus* Hall.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 169, pls. 31 and 31A.

A specimen of this species was obtained from Zone X. In Zone A there are great numbers of *Tentaculites*, but in such a poor state of preservation that it is impossible to make a specific identification.

Family TORELLELLIDÆ Holm.

Genus COLEOLUS Hall.

202. *Coleolus tenuicinctum* Hall.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 185, pls. 32 and 32A.

A number of very good specimens of this species were found in various parts of the section.

Family HYOLITHIDÆ Nicholson.

Genus HYOLITHES Eichwald.

203. *Hyalithes aelis* Hall.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 197, pls. 32 and 32A.

Although this is a rare species at Cayuga Lake, in the aggregate the number found is quite large. The variations consist in the relative difference in length, width, and thickness. The measurements are 30, 30, 25 mm. in length and 9, 11, and 12 mm. in width. Two well-preserved operculæ were found.

204. *Hyalithes striatus* Hall.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 199, pl. 32.

A specimen with well-marked longitudinal lines was found in Zone T.

Genus CONULARIA Miller.

205. *Conularia undulata* Conrad.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 208, pls. 33 and 34A.

A fragment of a large specimen of this species with very strong surface markings was found in Zone D. A fragment of a smaller individual was taken from Zone I.

Class CEPHALOPODA.

Subclass TETRABRANCHIATA Owen.

Order NAUTILOIDEA.

Suborder ORTHOCHOANITES Hyatt.

Family ORTHOCERATIDÆ.

Genus ORTHOCERAS Breynius

206. *Orthoceras crotalum* Hall.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 296, pls. 42, 82, and 93.

This fossil is found occasionally throughout the section above Zone D. The test is often denuded, making the identification in some cases uncertain.

207. *Orthoceras cælamen* Hall.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 298, pls. 42, 43, 82, 113.

A few specimens with the characteristic surface marking were obtained from the Upper Hamilton shales.

208. *Orthoceras nuntium* Hall.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 299, pls. 43 and 82.

This is a rare fossil in this section. Two specimens were found in the Upper Hamilton.

209. *Orthoceras subulatum* Hall.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 283, pls. 38, 84, 86.

This species of *Orthoceras* is not uncommon along Cayuga Lake. A large number of distorted specimens of this genus were referred here with some doubt. One specimen showed the surface markings.

210. *Orthoceras constrictum* Vanuxem.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 288, pls. 84, 85.

This is a rather rare species in this section, and is not reported west of Cayuga Lake.

211. *Orthoceras exile* Hall.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 290, pls. 39, 84, 85.

A few specimens were doubtfully placed in this species.

212. *Orthoceras marcellense* Vanuxem.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 278, pls. 38, 83, and 113.

A specimen from the Marcellus seems to be of this species.

213. *Orthoceras*, sp. undet.

This genus, as a whole, is common between Zones B and F, inclusive, and in Zone T. Elsewhere in the section this genus was rare.

Family NAUTILIDÆ.

Genus NAUTILUS Breyn.

214. *Nautilus liratus juvenis* Hall.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 411, pl. 56.

James Hall describes this variety of *N. liratus* from an imperfect specimen and states that the determination is quite unsatisfactory. Two fairly well-preserved specimens from the hard shales of the upper Marcellus are certainly distinct from *N. liratus* and answer to the description of *N. liratus juvenis*. The difference between these specimens and *N. liratus*, however, seems to be specific rather than varietal.

215. *Nautilus*, fragments.

A number of fragments of *Nautilus* found in various parts of the section were too imperfect for specific identification.

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Suborder CYRTOCHOANITES Hyatt.

Family PHRAGMOCERATIDÆ.

Genus GOMPHOCERAS Sowerby.

216. *Gomphoceras*, sp.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 318.

A single crushed specimen of this genus was found in Zone C. The markings were obliterated to such an extent that it was impossible to make a specific identification.

Order AMMONOIDEA.

Suborder EURYCAMPYLI Hyatt.

Family GLYPHIOCERATIDÆ.

Genus GONIATITES de Haan.

217. *Goniatites discoidens* Hall.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 441, pls. 71, 74.

Casts of the test showing the fine, closely arranged striæ, "raised at intervals in fascicles," were commoner than those showing the septa. This species was fairly common in Zone T. In Zone I a number of imperfect specimens which were either of this species or of *G. uniaangularis* were quite frequently found. Elsewhere in the section they are very rare.

218. *Goniatites uniaangularis* Conrad.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 444, pls. 71, 74.

This species was very rare, but several well-preserved specimens were found. One almost perfect small specimen from the lower shales of Zone C measured 15 mm. in diameter in the widest part. A large specimen measured 45 mm. in diameter.

Subkingdom ARTHROPODA.

Class CRUSTACEA.

Subclass TRILOBITA.

Order OPISTHOPARIA Beecher.

Family PRÖETIDÆ Barrande.

Genus PRÖETUS Steininger.

219. *Prœtus rowi* Green.

Pal. N. Y., vol. 7, 1888, p. 119, pls. 21 and 23.

A portion of the cephalon with a crushed glabella and a perfect genal spine was referred, with some doubt, to this species,

220. *Prætetus microgemma* Hall.

Pal. N. Y., vol. 7, 1888, p. 109, pl. 22.

An imperfect pygidium was referred with considerable certainty to this species.

221. *Prætetus macrocephalus* Hall.

Pal. N. Y., vol. 7, 1888, p. 116, pls. 21 and 23.

A pygidium and thorax were found in Zone Y and a glabella in the Encrinal bed. The surface markings are quite plain.

Genus HOMALONOTUS Koenig.**222. *Homalonotus dekayi* Green.**

Pal. N. Y., vol. 7, 1888, p. 7, pls. 2, 3, 4, 5.

This is quite a common fossil in the upper portion of the Encrinal band. A fragment of a pygidium was found in Zone Y and a portion of a cephalon in Zone D. At Eighteenmile Creek it is reported from the lower portion of the Lower Hamilton. In Kashong Creek it occurs rarely in the Upper Hamilton.

Order PROPARIA Beecher.**Family PHACOPIDÆ Salter.****Genus PHACOPS Emmrich.****223. *Phacops rana* Green.**

Pal. N. Y., vol. 7, 1888, p. 19, pls. 7, 8, 8A.

This is a common and sometimes an abundant species in this section. Above the Encrinal it occurs in almost every zone. Occasionally a complete specimen was found. It is usually associated with *D. boothi* and *A. umbonata*.

224. *Phacops cristata* var. *pipa* Hall.

Pal. N. Y., vol. 7, 1888, p. 18, pl. 8.

A specimen of this variety was found in Zone A.

Genus DALMANITES Emmrich.**225. *Dalmanites boothi* Green.**

Pal. N. Y., vol. 7, 1888, p. 42, pls. 16, 16A.

This species was found in the lowest portion of Zone C. It is common throughout the section from Zone D to the Tully, especially above the Encrinal.

At Eighteenmile Creek it is commonest below the Encrinal, while at Cayuga Lake the opposite is true.

226. *Dalmanites boothi* var. *calliteles* Green.

- Pal. N. Y., vol. 7, 1888, p. 45, pls. 16, 16A.

A few specimens of this variety were found in the upper portion of the Upper Hamilton.

Subclass EUCRUSTACEA Kingsley.

Superorder MALACOSTRACA Latreille.

Order PHYLLOCARIDA Packard.

Suborder Ceratiocarina Clarke.

Family ECHINOCARIDÆ Clarke.

Genus ECHINOCARIS Whitfield.

227. *Echinocaris punctata* Hall.

Pal. N. Y., vol. 7, 1888, p. 166, pls. 27, 28, 29.

Five specimens of this species were found in the Cayuga Lake section, one in the Upper and four in the Lower Hamilton above Zone D.

Genus TROPIDOCARIS Beecher.

228. *Tropidocaris hamiltonise* Hall.

Pal. N. Y., vol. 7, 1888, pl. 30.

A right valve of this species was found in Zone O. It measured 10 mm. in length.

Suborder RHINOCARINA Clarke.

Family RHINOCARDIDÆ Clarke.

Genus RHINOCARIS Clarke.

229. *Rhinocaris* sp.

Pal. N. Y., vol. 7, 1888, p. lviii, pl. 31.

Two specimens of this genus, one with both valves, the other with one valve of the carapace were found in the shale of Zone C along Dean Creek. The preservation was too imperfect to permit of specific identification.

Genus MESOTHYRA Hall and Clarke.

230. *Mesothyra oceani* Hall.

Pal. N. Y., vol. 7, 1888, p. 187, pls. 33 and 34.

Two specimens of this genus were referred doubtfully to this species. Neither specimen is perfect enough to warrant a specific identification. The length of the carapace is 20 mm. and 45 mm., respectively.

231. Superorder OSTRACODA Latreille.

The various species and genera of this superorder seem to have been adapted to the same conditions of environment during the Hamilton stage. They are common in the fine shale of Zones B, C, and E.

PLANTÆ.

Genus LEPIDODENDRON Sternberg.

232. *Lepidodendron gaspianum* Dawson.

Quar. Jour. Geol. Soc., 1859, vol. 15, p. 484.

A specimen of this plant with distinct imprints of the leaves was found in Zone C.

Thanks is due Professor Penhallow for the identification.

233. Plant fragments.

Plants, usually in a poor state of preservation, were scattered throughout the section. Within a foot or two of the Tully limestone plant fragments were especially well preserved and abundant.

Genus TAONURUS.

234. *Taonurus* sp.? Fischer-Ooster.

This fucoid was very abundant in the upper portions of the Upper and Lower Hamilton.

CHAPTER V.

COMPARISON OF THE CAYUGA LAKE SECTION WITH OTHER SECTIONS OF THE HAMILTON FORMATION.

BASAL LIMESTONE.

The Basal limestones of Ontario County are described by J. M. Clarke, as follows:^a

Within 10 feet of the top of the Marcellus shales, where the rocks still retain their characteristic color and diagnostic fossils, appear *Spirifer mucronatus* and *Ambocelia umbonata* of the Hamilton fauna, such Hamilton species increasing in number and the rocks becoming less and less bituminous until at the top of 10 feet the bituminous character has disappeared and with it the Marcellus fauna. Overlying is a series of strata of limestone more or less impure and persisting throughout the county east and west.

Farther east the same strata become more shaly and lose many of the fossils of the richer western outcrop. Dr. D. F. Lincoln^b accepted the term "Basal Hamilton," proposed by J. M. Clarke, and the description of Hall in the report of the Fourth District^c—"a compact calcareous blue shale passing into an impure limestone." He says that it retains this character (of a coral reef) to some extent in Seneca County, displaying scattered fragments of *Heliophyllum*, *Favosites*, and other large corals which do not belong elsewhere in the region.

From the description given above and from its position in the section (see map Pl. I) it seems certain that the compact calcareous shales of Zone D should be correlated with the Basal Hamilton of Ontario and Seneca counties.^d There is, however, considerable difference in the faunules. Although the corals are very much rarer in Zone D at Cayuga Lake compared with that stratum in the west, yet *Heliophyllum* is common only in this stratum in the Cayuga Lake section. This zone is characterized in Ontario County by a great abundance of Crustacea. The development of Crustacea in Zone D is by no means remarkable, only three species of trilobites being found, none of which were abundant.

^a Report State Geol., New York, 1885.

^b Ibid., 1894.

^c 1843.

^d Since the above was written the author revisited the localities on Seneca Lake. There is no doubt as to the correctness of the correlation.

A comparison of the Basal Hamilton of Ontario County, Seneca County, and Zone D of Cayuga Lake shows a decrease in the amount of calcareous matter and in corals from west to east. It is probable that the region along Cayuga Lake was the edge of the reef, if such it can be called, and that the conditions were such that most of the species of corals and Crustacea which flourished so well in the west were represented in the Cayuga Lake region by an abundant brachiopod and pelecypod fauna, with here and there a large *Heliophyllum halli* and a colony of *Syringopora*.

This impure limestone layer, the Basal Hamilton, is, next to the Encrinal beds, the most persistent stratum in the New York Hamilton, extending as it does for more than 40 miles from east to west.

I. P. Bishop, in the Geology of Erie County, mentions^a a calcareous stratum in that county which he correlated provisionally with the Basal limestone of Clarke. The evidence for this correlation is so unsatisfactory that it must be disregarded.

ENCRINAL BEDS.

In comparing the faunules of the Encrinal beds with that of Eighteenmile Creek, it was found that of 8 lamellibranchs of the Eighteenmile Creek Encrinal 4 are found in the Encrinal of the Cayuga Lake section, 2 are extremely rare, and 2 have been found nowhere in this section. Of the 35 brachiopods, 13 were not found in the Encrinal of Cayuga Lake. But of that number 4 have not been found elsewhere in the section and 4 are extremely rare. *Vitulina pustulosa*, *Centronella impressa*, *Meristella haskinsi*, and *Heliophyllum confluent* are restricted to the Encrinal at Eighteenmile Creek. With the exception of *V. pustulosa* and *M. haskinsi*, which was found in the Encrinal and Zone D, these species are restricted to the Encrinal at Cayuga Lake. Grabau^b finds the Encrinal at Eighteenmile Creek to be the equivalent of that at Livonia. The comparison of the fossils from that stratum in the two places brings out the fact that only one species given in the Livonia list is wanting in the limestone at Eighteenmile Creek. James Hall^c considered the Encrinal as a "persistent mass holding only one position in the group and continuous as far as Lake Erie. It is a convenient point of reference." It is 1½ feet thick at Lake Erie, 2 feet at Livonia, 3 feet in Yates County, and 1½ feet in Cayuga County.

Prof. C. S. Prosser,^d in discussing Professor White's correlation of a zone in eastern Pennsylvania which is as rich in corals and crinoids as the Tully, shows by the fossil content that the Genesee shales of White are Hamilton shales. The so-called Tully does not contain any

^a Report State Geol. New York, 1886.

^b Report State Geol. New York, 1898.

^c Report Fourth District New York, 1843.

^d Bull. U. S. Geol. Survey No. 120, 1894, p. 74.

characteristic Tully fossils, but contains only Hamilton species. He says:

If a correlation of this zone with one of central and western New York were attempted, I would suggest the Encrinal limestone separating the fossiliferous argillaceous Ludlowville and Moscow shales. As the Pennsylvania horizon may be represented by any one of the several coral horizons in the Hamilton of New York or by an entirely different one, such a correlation of this zone is very hazardous without careful comparison of the species and stratigraphy.

On the east shore of Skaneateles Lake, $2\frac{1}{2}$ miles from the head of the lake, is a bed of cyathophylloid and other genera of corals 5 feet thick, which are described by Luther.^a Luther concludes, from its position and from the fact that it "abounds in cyathophylloid corals which characterize the Encrinal of the western counties," that it is probably the eastern extension of the Encrinal band. Since in Ontario, Seneca, and Cayuga counties the most abundant coral faunas are in the Basal Hamilton, either this coral reef at Skaneateles Lake is (1) a continuation of the stratum called the "Basal Hamilton," which is several hundred feet above the Marcellus shales in the Cayuga Lake section, or (2) the Encrinal, or (3) the union of (1) and (2), or (4) a separate stratum. With the data now at hand Luther's supposition is as probable as any other.

Since the Encrinal is found in a number of localities between Lake Cayuga and Lake Erie, of the same lithological character, in relatively the same position in the shale, with a fauna which changes little in a distance of 125 miles, it should be considered as a continuous stratum. East of Cayuga Lake the correlation of the coral zones is yet to be worked out. However, conditions of sedimentation such as would produce a limestone stratum anywhere in the Middle Hamilton would be adapted to and contain what might be called a limestone fauna which would not differ materially from the fauna of the Encrinal; and whether this stratum were continuous or not, the same association of fossil would probably exist.

GASTEROPODA.

Gasteropoda predominate both in specific and in individual development in the lower shales of Ontario County. This is also the condition at Eighteenmile Creek, where only one gasteropod, *Platystoma lineata*, is found above the Encrinal, and that but rarely in one layer. In the Cayuga Lake section Gasteropoda are not common in any portion of the section, but are about as frequently met with above as below the Encrinal. They occur, however, rather more frequently, in proportion to the Pelecypoda and Brachiopoda, in the fine shales of Zone C.

^a Report State Geol. New York, 1895.

USE OF TERMS "UPPER" AND "LOWER" HAMILTON FAUNA.

The data at hand—the faunules of the Cayuga Lake, Eighteenmile Creek, and Livonia sections—are sufficient to warrant some definite statement as to the propriety of the terms "an Upper Hamilton fauna" or "a Lower Hamilton fauna," used by some writers as signifying an ability to distinguish between them.

A comparison of the Cayuga Lake section with that of Eighteenmile Creek shows that the relative abundance of species and individuals in the Upper and Lower Hamilton of the two sections is reversed. At Cayuga Lake the number of species and individuals is greater above than below the Encrinal beds, while the opposite is decidedly true of the Eighteenmile Creek section.

Spirifer granulosus is a rather common fossil above and below the Encrinal at Cayuga Lake, but is restricted to the Lower Hamilton and the Encrinal at Eighteenmile Creek and to the Upper Hamilton at Livonia. *Reticularia fimbriata*, *Tropidoleptus carinatus*, and the lingulas are distributed in the three sections in the same manner as *Spirifer granulosus*.

Stropheodonta concava and *S. junia* are in the Lower Hamilton at Eighteenmile Creek, but are restricted to the Upper Hamilton at Cayuga Lake and Livonia.

Only two species of Brachiopoda have been found, which are restricted to the Upper Hamilton of the three sections, exclusive of the Encrinal—*Ambocælia præumbona* and *Spirifer marcyi*. But it would not be remarkable if even these were found lower. Since these species have not been reported east of Cayuga Lake, they must of necessity have little use in stratigraphy. *Ambocælia præumbona* has not been reported outside of New York State, and it may have originated in western New York after the Encrinal band was deposited.

Leiorhynchus limitare, *Spirifer macrus*, *Anoplothea camilla*, and *Strophalosia truncata* are species which have not been reported above the Encrinal beds. The first is a typical Marcellus fossil (reported by Clarke^a in a "recurrent fauna" above the "Basal limestone" in Ontario County); the second and third are typical Onondaga (Corniferous) species which have never been found above the Marcellus; only the fourth, *Strophalosia truncata*, is a species often found in the Hamilton. A comparison of the corals, pelecypods, and gasteropods brings the same results.

From the above it will be seen that the burden of evidence at present is against the supposition that it is possible, without the aid of stratigraphy, to distinguish between the Upper and Lower Hamilton fauna. However, the presence of *Spirifer marcyi* and *Ambocælia præumbona* and the absence of *Strophalosia truncata* in a fauna would be presumptive evidence of the Upper Hamilton.

^a Rept. State Geol. New York, 1886.

EXPLANATION OF DIAGRAM, FIG. 3.

The data from which this diagram was constructed were obtained from the New York Geological Reports, commencing with vol. 4, 1867, Palæontology of New York, together with the Peabody Museum collections from Onondaga, Cayuga, Seneca, Genesee, and Erie counties used in the preparation of this paper. The distances are only approximate, some noted collecting locality being usually taken as a center.

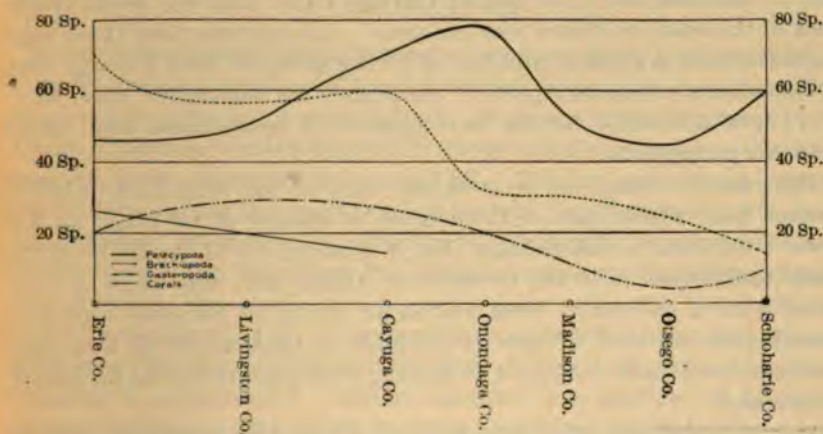


FIG. 3.—Diagram showing the distribution of fossils of the Hamilton stage throughout New York State.

The curves from Onondaga County west are probably more nearly correct than those east, because of the exceptionally careful collections from Pompey, Cayuga Lake, Livonia, and Eighteenmile Creek. The faunal lists of Prof. C. S. Prosser^a make the collections from the extreme eastern portion of the State fairly full.

As is readily seen, the center of abundance of Pelecypoda is in Onondaga County. From that point the decrease to the west is rapid. The decrease in the number of species of Pelecypoda in the arenaceous shales east of Onondaga County would probably be less than represented were fuller collections to be had. That the conditions in eastern New York were much less favorable to the development of brachiopods than of pelecypods is shown by the fact that the relative abundance of brachiopods to pelecypods in Schoharie County is 13:60, while at Lake Erie the ratio is 70:40.

The increasing abundance of species of brachiopods from east to west is very striking and uniform. The line showing the abundance of Gasteropoda varies less from east to west than the other classes. The data concerning the corals show a uniform increase between Cayuga and Erie counties.

^a Fifteenth Ann. Rept. State Geol. New York, 1895.

Two facts should be borne in mind in the consideration of the relative abundance of fossils when studied geographically, (1) the excellent opportunities for collecting in certain localities, as central and western New York, and the greater difficulty in others, as the eastern counties of New York, and (2) the fact that often in a formation the same time elapsed during the deposition of a few feet of sediment in one place that it took for the deposition of many times that thickness in another locality in the formation. The time required for the deposition of the 67 feet of sediment at Eighteenmile Creek, the 517 feet at Livonia, the 1,100 feet at Cayuga Lake, and the great thickness of the eastern shales was the same. At any one time there may not have been a greater number of living shells in Erie County than in the central or eastern part of the State; the conditions were, however, more favorable for the development of brachiopods and corals than for pelecypods.

The change from east to west, not only in the relative number of species but in the species themselves, is spoken of by Hall^a as follows: "So great is this change that if a collection of fossils from the Hamilton formation in the counties of Albany and Schoharie be compared with a collection from the same group in Genesee and Erie counties the number of species common to both would be less than has been sometimes indicated as passing from one geological formation to another."

^a Preface to Pal. New York, vol. 4, 1867.

CHAPTER VI.

CONCLUSIONS.

In this investigation the following conclusions have been reached:

(1) There are a number of fossil faunules in the Hamilton formation which can be quite accurately defined. A glance at the diagrams Pl. V, A and B, and the table (Appendix) shows the distinctness with which many of these faunules are marked off. On the present sea bottom it is possible, given the conditions of bottom, depth, temperature, etc., in any region, to state with considerable certainty the composition of the faunule. The boundary line between modern faunules is sometimes distinct, but often there is such a mixture of the two faunules at the boundary that it is impossible to state where the line should be drawn. In the vertical distribution of fossil faunules the same difficulty is encountered. Shales containing a mixture of faunules are not uncommon, but where uniform conditions prevailed for a considerable length of time a definite group of species occurs. Occasionally the change was sudden, and the faunules are separated by a distinct line. Zone D is an excellent example of such a case; the shales above and below are almost barren of fossils, while Zone D is very fossiliferous. Occasionally a thin layer of fine shale is seen in the midst of a fossiliferous zone, or a thin layer rich in fossils in a barren zone.

(2) The difference between the composition of different faunules of the Hamilton formation is often more marked than between faunules of the same facies belonging to different formations. A study of living faunules leads one to expect such a condition, since in a short distance bathymetrically and geographically there is often a complete change in species.

(3) Migration of the organisms which lived during the Hamilton stage was undoubtedly accomplished in the same way as at present.^a Such animals as Crustacea and *Orthoceratiles* had considerable power of movement in the adult condition, but the common fossil animals, such as the brachiopods and pelecypods, were practically stationary when mature. The only means of migration for such classes was during the free swimming stage. During this stage they were carried about by currents and to some extent moved by their own activity.

^aSee Parker and Haswell, Text-Book of Zoology, and other Zoologies. Marine Bionomy. Graban.

Zoologists cite many cases of the sudden appearance of species previously unknown to certain localities which were carried there during the free swimming stage by unusual conditions. These species often live but one year, and may not be seen again for years. Drifting timber and other means enable old and young of certain species to be carried long distances. The migration of the species making up the bulk of the Hamilton faunules undoubtedly took place, for the most part, during the free swimming stage.

(4) The repetition of faunas such as are found in a section like that of Cayuga Lake shows that there was an oscillation of similar conditions. It is probable that had the conditions remained uniform during the whole of the stage only one of these faunas would have occurred. The *Leiorhynchus* zone is several hundred feet thick in this region. There is no objection to the supposition that such a faunule would have lived on throughout the stage had the conditions remained as they were during the deposition of that zone.

(5) An "accidental" faunule is one which has been produced in a long period of time in a region where sedimentation has been very slight, but in which the conditions changed for short periods sufficiently to introduce a few species. In the aggregate the number of species of such a faunule may be great. A faunule of this character is very confusing, composed, as it is, of species from perhaps several faunules. It was not unusual for a thousand or more feet of sediment to be deposited in one region, while in another, during the same period of time, only a few feet were laid down. It is consequently unsafe to say, because fossils are abundant in a few inches of shale, that the conditions were necessarily exceptionally favorable for the development of that faunule. It is not impossible that hundreds or even thousands of years may have elapsed during the deposition of such a zone. The comparison of the thickness of the Hamilton formation at Cayuga Lake with that at Eighteenmile Creek showed that while 1,100 feet of shales were deposited in the Cayuga Lake region only 67 feet were deposited at Eighteenmile Creek. On the other hand, that great length of time and little sedimentation are not necessary for the formation of all fossiliferous zones is evident from the peculiar and characteristic faunules of these zones and the position of the fossils in the shale and limestone.

(6) In a section such as that of the Hamilton formation at Cayuga Lake, which represents in its formation between 1,846,150 and 26,153,840 years,^a if the statement "*natura non saltum facit*" is granted, one should, with some confidence, expect to find many—at least some—evidences of evolution. A careful examination of the fossils of all the zones, from the lowest to the highest, failed to reveal any evolutionary changes, with the possible exception of *Ambocælia preumbona*.

^a The first estimate is from Dana; the second is the maximum of Geikie. The Meso-Devonian was estimated as one-third the Devonian.

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The species are as distinct or as variable in one portion of the section as in another. Species varied in shape, in size, and in surface markings, but these changes were not progressive. The conclusion must be that, so long as the conditions of sedimentation remain as uniform as they were in the section under consideration, the evolution of brachiopods, gastropods, and pelecypods either does not take place at all or takes place very seldom, and that it makes little difference how much time elapses so long as the conditions of environment remain unchanged.

(7) An analysis of the Hamilton faunas shows conclusively that there is little basis for the terms "an upper" and "a lower Hamiltonian fauna" unless these terms are used to signify that it is possible in isolated sections to state, from the composition of the fauna, whether the rock is above or below the Encrinal bed.

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CHAPTER VII.

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30.	Camarotoechia congregata		R			r?	F		R
31.	C. dotis					R			R
32.	C. horsfordi					r?			R
33.	C. prolifica			r?		R			R
34.	C. sappho				R				r
35.	Hypothyris cuboides							B R A C A C	
36.	Leiorhynchus laura	Cr?	C	R	C	R			
37.	L. limitare		C						
38.	Centronella impressa						C		
39.	Cryptonella planirostris		r						
40.	C. rectirostris		Cr						
41.	Eunella linckeani		Cr			Cr			
42.	Tropidoleptus carinatus		R	R	r	C	Cr	C	A CA C
43.	Atrypa reticularis		R	R	R				f
44.	Cyrtina hamiltonensis		Cr						R R
45.	Spirifer audaculus		Cr			R	Cr	R	f Cr
46.	S. audaculus macromotus		r			r	R		R CA
47.	S. divaricatus		R						f A Cr
48.	S. granuloseus		R		R				R
49.	S. marcyi		R		R				R*
50.	S. pennatus		R	r		Cr	Cr		R
51.	S. tullius		R	r	Cr	C	A	C	B CA A CA
52.	S. macrus	C				Cr			r
53.	Delthyris consobrina		R			R			C R
54.	D. sculptilis		r						C Cr
55.	Martinia subumbona								Cr
56.	Ambocella preumbona								Cr
57.	A. umbonata	Cr	Cr	C	r	R	Cr	A	R R
58.	Reticularia flabriata		Cr						r Cr
59.	Nucleospira concinna		r			Cr			R
60.	Anoplothecca camilla	Cr							
61.	Vitulina pustulosa		Cr			Cr			
62.	Athyris spiriferoides	CA	Cr		R	CA	B	CA	r A A Cr
63.	Meristella haskinsi		R						
64.	Orbiculoides doria		R						R

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APPENDIX.—Table showing vertical distribution of faunal zones, with their contained faunules, in the Hamilton formation of Cayuga Lake, New York—Continued.

	Marcellus.			Lower Hamilton.								Encrial bed.	Upper Hamilton.												
	Hamilton-Onondaga (Corniferous) zone.	First Leiorhynchus zone.	Second Leiorhynchus zone.	First Terebratula zone. (See text.)	Third Leiorhynchus zone.	Michellina zone.	Chonetes vicinus zone.	(Transition zone.)	First Cypricardella-Athyris zone.	Tellinopsis zone.	Second Cypricardella-Athyris zone.		Second Terebratula zone.	Orthonta zone.	(Transition zone.)	Chonetes zone.	First Ambocella zone.	Chonetes lepidus zone.	Second Ambocella zone.	Stropheodonta-Coral-line zone.	Modiola pygmaea zone.	Ambocella preumbona zone.	Orbuloides zone.	(Transition zone.)	Splinter-Athyris zone.
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y

PRELECYPODA—continued.

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APPENDIX.—Table showing vertical distribution of faunal zones, with their contained faunules, in the Hamilton formation of Cayuga Lake, New York—Continued.

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[Bulletin No. 206.]

The serial publications of the United States Geological Survey consist of (1) Annual Reports, (2) Monographs, (3) Professional Papers, (4) Bulletins, (5) Mineral Resources, (6) Water-Supply and Irrigation Papers, (7) Topographic Atlas of United States—folios and separate sheets thereof, (8) Geologic Atlas of United States—folios thereof. The classes numbered 2, 7, and 8 are sold at cost of publication; the others are distributed free. A circular giving complete lists may be had on application.

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THE PALEOLITHIC PERIOD
THE NEOLITHIC PERIOD

HERMAN F. GLELAND

[Reprinted from the *Encyclopedia Americana*, 1919]



from which the reformation of the book-hand spread. In the 9th century the minuscule had attained a degree of elegance and clearness that left little to be desired, as appears from the following specimen:

*accipere marium coniugem utam quod
enim ex ea nascetur de spiritu sancto e.t. Pariet
autem filium et uocabis nomen eius iesum.*

Caroline Minuscules, 9th Century.

(accipere marium coniugem utam quod
enim ex ea nascetur de spiritu sancto e.t. Pariet
autem filium et uocabis nomen eius iesum).

From that style to our modern characters, either script or print, was an easy step.

Paleography may be said to have been the learned French Benedictine, whose 'De Re Diplomatica' printed 1709 and 1789, in 2 vols. perhaps, the most masterly work on the subject. With the 'Nouveau Traité de Diplomatique' (Paris 1750-65, 6 vols. 4to) of the Benedictines of Saint Maur, and the 'Eléments de paléographie' (Paris 1838, 2 vols. 4to) by M. Natalis de Wailly, is the great authority for French paleography. English paleography is perhaps less favorably represented in Asple's 'Origin and Progress of Writing' (London 1803) than Scottish paleography in Anderson's and Ruddiman's 'Diplomata Scotiæ' (Edinburgh 1739). Muratori treats of Italian paleography in the third volume of his great work, 'Antiquitates Italicæ Medii Ævi'; and among later works on the same subject may be mentioned 'Diplomatica Pontificia' (Rome 1841) of Marino Marini. The paleography of Greece is illustrated in 'Paleographia Græca' (Paris 1708) of Montfaucon. Spanish paleography may be studied in 'Biblioteca de la Poligrafía Española' (Madrid 1738) of Don C. Rodríguez. Of works on German paleography it suffices to name Eckard's 'Introductio in Rem Diplomaticam' (Jena 1742), Heumann's 'Commentarii de Re Diplomatica' (Nuremberg 1745), Walther's 'Lexicon Diplomaticum' (Göttingen 1745) and Kopp's 'Paleographia Critica' (Manheim 1817). Hebrew paleography has been elaborated by Gesenius in 'Geschichte der Hebräischen und Schrift' and other works. The great work on paleography generally—one of the most sumptuous works of its class ever published—is 'Paléographie Universelle' (5 folio vols., Paris 1839-45) of M. J. B. Silvestre.

Consult Mas Latrie, J. M. J. L. de, 'Dictionnaire de paléographie' (Paris 1854); Moore, M. F., 'Works Relating to English Palæography' (London 1912); Saunders, W., 'Ancient Handwritings: Manual for Students of Paleography' (Walton-on-Thames 1909); Silvestre, J. B., 'Paléographie universelle' (Paris 1841); Thompson, E. M., 'Greek and Latin Paleography' (London 1894); Thoyts, E. E., 'How to Decipher and Study Old Documents: A Guide to the Reading of Ancient Manuscripts' (London 1893); Wailly, J. N. de, 'Eléments de paléographie' (Paris 1838); Quaritch, B., 'Catalogue of Manuscripts and Books Illustrating the Science of Paleography' (London 1893).

PALEOLITHIC PERIOD, The. The second period of prehistoric man is the Paleolithic (Greek, *paleos*, ancient, and *lithos*, stone), the first period being the Eolithic. In this stage of his development man made his implements of flint by chipping off flakes until the desired form was obtained, but as far as known he never polished them afterward, the art of polishing stone implements being introduced near the beginning of the Neolithic. It is on this basis,—the absence of polished stone implements in the deposits of the Old-Stone Age and their presence in those of the Young-Stone Age,—that the names Paleolithic and Neolithic are given. The makers of Paleolithic implements probably did not belong to a single race of men, but rather to several races. Of these races two seem to have been especially important: the Neanderthals, who lived during the older Paleolithic and the Cro-Magnons, who replaced them, and who seem to have been the dominant people of the younger Paleolithic. In general, it can be said that during the period under discussion man became progressively more dextrous in making stone implements and that toward its close, when bone and ivory were replacing stone, skill in working flints declined.

Proofs of Antiquity.—Great difficulty is often encountered in determining the age of the remains and implements of paleolithic man; many mistakes have been made and investigators have differed widely as to the interpretation of the same evidence. Nevertheless, when all the evidence is carefully studied, it is found that the broad outlines of the history of the Old Stone Age can be accepted, even though the details are sometimes in doubt.

The proofs of man's antiquity and the relative age of his remains and implements are determined by several lines of evidence:

(1) The association of his remains and implements with the bones of extinct animals is a convincing proof of man's antiquity when it can be established that these bones and tools were deposited at the same time. For example, in France, England, and elsewhere the bones of extinct elephants, rhinoceroses, lions, and other animals are found with the remains of man. In other deposits the arctic woolly rhinoceros, woolly mammoth, and reindeer are found with his skeletons and tools. These animals have long been extinct in the countries in which their remains are now found, and the climate in these countries has radically changed since then.

(2) The proof of the age of man's remains is also afforded by deposits in caves as the relative age of his implements and bones is shown by the superposition of the layers in which they occur. No one cave affords a complete record of the Paleolithic Period, but by piecing together the evidence from different caves the relative antiquity of cave deposits has been unraveled, so that it is now often possible to tell the age of the deposit from the stage of development of the implements, as well as from the animal remains. A single example, that of Kent Cavern, Devonshire, England, will suffice to illustrate this method of determining the relative age of deposits. As the material which partly filled the cavern was excavated, three distinct layers were encountered, in addition to two sheets of stalagmite, a rock formed by lime dripping from the roof of the cave.

(a) The surface was composed of dark earth containing mediæval remains, Roman pottery, and objects of iron, bronze, and stone, showing that man inhabited the cave at intervals from Neolithic to Roman times.

(b) Below this surface layer was a bed of stalagmite one to three feet thick. This covered a reddish deposit known as cave-earth, which contained a number of relics made of stone, bone, and horn. The flints were shaped into tools designed for various purposes. The bone implements were in the form of pins, awls, barbed-harpoons, and neatly formed needles. Associated with these implements were the bones of extinct animals, among which were fragments of the skeletons of the cave hyena, horse, rhinoceros, gigantic Irish deer, wild boar, bison, mammoth, cave bear, cave lion and sabre-tooth tiger. All of these animals are of species now extinct, not only in England, but throughout the world.

(c) The bottom of the cave was filled with broken fragments of rock (breccia) containing the remains of the cave bear, together with flint implements of a much cruder type than those in the layers above.

It is evident from this description that thousands of years were required for the filling of this cave. The bones of bygone animals that either had their lairs in the cave or whose carcasses were dragged there by ancient extinct carnivores is proof of the great antiquity of the lower deposits. The last of these animals, so far as we know, disappeared many thousands of years ago. The thickness of the stalagmite beds formed by lime drip is another evidence of the antiquity of the underlying deposits. A bed of stalagmite, one to three feet thick, probably required a very long time for its formation, although favorable conditions might have caused a rapid deposition. The oldest of these deposits are many thousands of years old, but ancient as they are they were, nevertheless, laid down long after the ape-men had disappeared from the earth.

3 (d) In the valleys of the river Thames in England; or the Somme, Marne, and Seine in France; of the Inn in Austria; of the Rhine in Switzerland, and in the valleys of other European rivers are found series of terraces or benches. A careful study of these terraces shows that during glacial times the rivers flowing from the great ice sheets spread vast deposits of sand and gravel over the broad surfaces of their valleys. In many valleys these deposits were built to a height of 100 to 150 feet. Several times during the Glacial Period the ice sheets advanced, and at other stages, called interglacial, the glaciers practically or entirely disappeared from Europe and North America and the climate in these continents became warmer than it is at present. During these interglacial stages the streams flowing through the valleys are believed to have had smaller volumes and much less sand and gravel in proportion to the volume. Consequently they were able to cut into their ancient beds, forming narrower channels, through which they transported their own loads of sediment. In this way successive river terraces were formed, a descending series of gigantic steps along the sides of the valleys. In many valleys there are four of these terraces which correspond to the several glacial stages; in others

there are only three terraces. In general "the high terraces" are the oldest ones. The coarse river gravels of the high terrace of the Eure, for example, contain remains of an extinct elephant and of an extinct horse, showing that these animals lived when a broad stream carrying coarse gravel flowed at least 90 feet above the present stream. It is in or on the gravels of the high, middle, and low terraces and underlying the materials later deposited on them that the artifacts of man are found. Along the river Seine the "high terrace," 90 feet above the present level of the river, corresponds to the first glacial stage, whereas the "low terrace" is only 15 feet above the river and was built of gravels deposited much later when the river was nearly of its present size. The "high terrace" contains the bones of animals of the first interglacial stage, but none of man nor of man's stone implements, whereas the lower terraces have yielded flints of prehistoric man and the bones of more recently extinct animals.

4 (f) During parts of the second and third interglacial stages, the climate of Europe was arid and the fine dust of the glacial deposits was swept up and transported by the wind until it slowly settled over the continent. The time at which these dust or loess deposits were laid down can be dated by the fossils they contain and also by the stage in the development of the flint implements embedded in the loess, and the loess, in turn, when its age is known on other evidence, gives the age of the human artifacts.

5 (f) The tools which man made were gradually improved as he acquired greater skill and had better models to copy. Consequently, the older implements are, in general, cruder than the later ones or of a different type. Such evidence must be carefully weighed, however, since the skilled worker of later times occasionally discarded a partially worked flint because of some flaw in the stone and sometimes lost a flint which had been merely roughly fashioned. Such crude, unfinished flints have sometimes led to the belief in a greater antiquity than they possess.

Climate.—Geological evidence points to the Glacial Period as the time when paleolithic man lived in Europe and Great Britain. The Glacial Period, or Great Ice Age, was not a period of continuous cold but, as has been said, included stages when the ice largely withdrew from the continent. These are called interglacial stages. It seems well established that the Great Ice Age in Europe consisted of four glacial and three interglacial stages, and that it was during the second or third interglacial stage,—more likely during the third,—that paleolithic man reached European.

The fossils of animals and plants found with the remains of very ancient men (Chellean and Early Acheulean) show that the climate was warmer at that time than it is now in England, France, and Germany. The southern mammoth (*E. meridionalis*), straight tusked elephant (*E. antiquus*), and soft nosed rhinoceros (*R. merckii*), hippopotamus, sabre-tooth tiger and hyena indicate that the climate was genial. The leaves of the sycamore, maple, willow and Austrian pine, found in deposits of the third interglacial stage near Paris, denote a temperate climate, and an increasingly milder climate is indicated by the presence of the box,

fig tree, and canary laurel in slightly later deposits. The habit of these last two trees of flowering in winter shows that the winter temperature was not cold. The plants of still younger deposits (late Acheulen) show that the climate was again becoming colder. The increasing cold finally culminated in what is called the Fourth Glacial Stage. It was during this time of refrigeration that the men of the younger Paleolithic Period lived.

CLASSIFICATION OF THE PALEOLITHIC PERIOD.

Various classifications of the Paleolithic Period have been offered, each of which is based upon important principles. It has been divided into the Age of the River Drift Man and the Age of the Cave Man. These divisions rest on the observation that the implements of the earlier Paleolithic Period are more frequently found in the gravels of river terraces than in caves and that later ones are found chiefly in caves and rock shelters. As the animal and plant remains of the earlier Paleolithic indicate a genial climate, so the chief occurrence of older paleolithic implements on the terraces formed by the rivers of the time seems to signify that in this stage man lived principally in the open, probably protected only by crude shelters of bark, as did the recently extinct Tasmanians. As the climate became colder with the approach of the Fourth Glacial Stage, more adequate protection was sought and that afforded by cave and rock shelters common in portions of Europe was used. These caverns and rock shelters were inhabited at least during the colder parts of the year. It is evident, however, ^{that} caves and rock shelters would be used not only when the temperature was cold but also that when the climate was genial: for example, as a place of refuge during rain storms or when attacked by wild beasts or human enemies.

If the Paleolithic Period is divided according to the races which lived at the time, the terms Older and Younger can be advantageously used, since during the Older Paleolithic (Chellen, Acheulean, Mousterian) Europe was inhabited by the brutish Neanderthal men with their broad, flattish skulls and ape-like postures. The men of the Younger Paleolithic (Aurignacean, Solutrian, Magdalenian) were represented by the Cro-Magnon race, characterized by great heads, large stature, and modern aspect.

Another classification is based upon the conspicuous animals of the various stages.

Epoch of the Reindeer — Magdalenian
Epoch of the Mammoth and Woolly Rhinoceros (R. tichorhinus) — Mousterian
Epoch of the straight tusked Elephant (E. antiquus) and *Merck's Rhinoceros* (R. merckii).

The classification now generally accepted is based both on the characteristics of the races and upon their culture. It is as follows:

Old Stone Age: Paleolithic Period
Younger Paleolithic
 Azilian
 Magdalenian
 Solutrian
 Aurignacean
Older Paleolithic
 Mousterian
 Acheulean
 Chellen
 Prechellenian
Eolithic Period

Eolithic.—If man had suddenly appeared on earth in his present bodily and mental state it would perhaps be unprofitable to search for his beginnings, but such was not true. Man was evolved from lower animals and his skill in making stone implements was acquired slowly and laboriously. Because the ability to design and shape implements was of slow growth, it is evident that very early in his history the tools he used were those prepared for him by nature, such as he found in the river bed or in the shingle of the ocean shore. The difficulty of determining whether such fragments were intentionally broken by primitive man or were shattered by the forces of nature is evident. His requirements in the way of tools being very simple and the supply of material in the form of natural flakes and fragments of flint being very plentiful, the inventive powers of man remained dormant for ages. The stone hammer and the stone knife were the original tools. Both were picked up ready-made. A sharp-edged, natural rock fragment served for one, and a nodule or fragment served for the other. When the edge of the flake became dulled by use, the piece was either thrown away or the edge was retouched for further use. If hammer or flake did not admit of being held comfortably in the hand, the troublesome points or edges were removed or reduced by chipping. The stock of tools increased slowly with the slowly growing needs. As these demands multiplied and the natural supply of raw material diminished, the accidental flakes were supplemented by the manufacture of artificial flakes. The earliest stone implements are called *eoliths* and the period, the Eolithic period. It is a significant fact that in gravels of "the higher terraces" eoliths have been found but no true paleolithic implements. It is possible that *Pithecanthropus* (see MAN, PREHISTORIC RACES OF) was a maker of crude flint implements (eoliths) and probable that the Heidelberg and Piltdown men also made eoliths. Weapons and tools made from wood, however, without doubt, were the principal ones, just as they are with the gorilla to-day; but as they rapidly decay no trace of them remains.

Pre-Chellean Epoch.—Crude flint implements believed by some investigators to antedate the first well-established epochs of the Paleolithic (the Chellean) but to be subsequent to the Eolithic, are considered by others to belong to the Chellean. The general shape of the flint was due to chance and was adapted to a variety of purposes by crude flaking. It is possible that these stone tools were made by the Heidelberg and Piltdown races.

Chellean Epoch.—The first well-defined epoch of the Paleolithic is the Chellean, named for the village of Chelles on the banks of the Seine, about eight miles east of Paris, where many implements have been found in alluvial gravels which form a terrace. The Chellean culture also occurs at Saint Acheul near Paris, in England, and in Spain. In all of these deposits are found flints shaped by man in his early efforts to master his environment. As one would expect, these first attempts to fashion flints into implements are very crude, but it is evident at a glance that the workers were endeavoring to make tools of a definite form. The most distinctive implement of the

Chellean, as indeed it is of the next following epoch, has been given several names (*coup-de-poing*, *boucher*, *faustkeil*, *hand-stone*). The French term, *coup-de-poing*, which literally translated means "stroke of the fist," is the one in most common use. "Hand stone" has been suggested as an English equivalent. This tool is roughly almond-shaped, varying from about 4 to 10 inches in length, and in size and shape is not unlike two hands with the palms touching. The form varies greatly from somewhat disc-shaped and oval to poniard shaped. It is a rather heavy tool which could be used for many purposes. A thick butt end fitted the hand and when held by this end it could be used for hacking or sawing, for drilling holes, for cutting and stabbing, for scraping hides, and for other purposes. When held by the pointed end it could be used as a hammer. If it had been used with a helve or handle the edges would have been chipped off by the violent blows it received, but the flakes produced by wear are minute and not coarse. The *coup-de-poing* was, in fact, the one indispensable, "all around" implement. The gravel deposits of Saint Acheul alone are said to have yielded 20,000 specimens. It was almost the sole implement used by the men of Chellean times. "It was the outcome of long experience, and, in point of utility, combined the functions of the elaborate array of mechanical tools which ultimately, under changed conditions of life, came into requisition." (Munro). In fashioning *coups-de-poing* a large number of flakes were broken off. The shape of some of the flint fragments was slightly modified by breaking off a corner or an edge and in this way a variety of small, crudely-made tools were obtained.

In the course of time flint tools were made for special uses and the use of the *coup-de-poing* was consequently gradually discontinued. This development in the skill of working stone, however, was very slow and during the whole Chellean Epoch flint implements were crudely shaped.

No human skeletons of Chellean Age have been discovered. This is not surprising, as bones rapidly disintegrate when buried in gravels or left on the surface. The climate of France in this epoch was not very different from the present, as is shown by fossils of trees, leaves, and animals. Ancient elephants (*E. antiquus*), rhinoceroses (*R. merkü*), hippopotami and sabre-tooth tigers, however, indicate a slightly warmer climate than now prevails in the same region.

During Chellean times Europe extended far beyond its present limits, the English Channel did not separate England from France, and Ireland was joined to England. Spain was connected with Africa at Gibraltar, and Italy and Sicily were also joined to that continent. As a result of these land connections the Mediterranean then consisted of two inland lakes.

Acheulean Epoch.—Acheulean implements have been found in at least 30 localities in France, England, Spain, Portugal, Italy, Germany, Austria, Russia, and Poland. In fact, the Acheulean workers probably lived in all that portion of Europe not then covered by the great ice sheet. The name Acheulean was given to the epoch because the industry of the time is typically represented in the gravels of

the third terrace of the river Somme at Saint Acheul, France.

The implements manufactured by the men of Acheulean times are merely modifications of the Chellean. The *coup-de-poing*, or hand-stone, is more skilfully made and, with few exceptions, the entire surface is flaked, whereas in the Chellean stage a part of the surface of the nodule is retained. It is, in general, lighter than the older tool; and the edge, as a result of repeated chippings, is much better adapted for cutting. It is, however, not always easy to distinguish between the implements of the two epochs. In addition to the *coups-de-poing* are found planing tools, knives, drills, scrapers, and other artifacts whose use can merely be conjectured. It has been stated that from the beginning to the end of the Chellean and Acheulean there is not an implement that can be regarded as a weapon (Sollas). The explanation, apparently, is that the spears were made exclusively of wood as were those of the recently extinct Tasmanians. It has also been suggested that it was only after men began to live in caves that they took to hunting big game (Munro).

A large number of fragments of human bones and several entire leg bones were found in a recess in the banks of the Krapinica Brook, in Croatia, but there is doubt as to the age of these remains. Some investigators consider them to belong to the Acheulean epoch and others to the Mousterian.

During the greater part of the Acheulean epoch the animal life was practically the same as in the preceding epoch: the straight-tusked elephant, Merk's rhinoceros, a horse which is believed to be the ancestor of some of our modern draft horses, the hippopotamus, and other animals abounded. Besides the common Chellean animals were hyenas, brown bears, wild boars, and lions. Some of the lions and hyenas are ancestors of the cave types which appear in the succeeding Reindeer and Cavern epochs, i.e., in the Younger Paleolithic.

The climate of the earlier Acheulean, as shown by animal and plant fossils, was warm. This is also indicated by the distribution of the Acheulean camps which are, for the most part, in the open country on the divides between rivers and on river terraces. Later in the epoch a colder, dry climate is indicated by the plants preserved in the travertine of La Celle-Sous-Moret, near Paris. It is possible that before the close of the epoch the continental ice sheet of Scandinavia began to move southward. Some Acheulean implements are said to be associated with the remains of the woolly rhinoceros and mammoth, but this association does not necessarily prove that the climate in the vicinity of the river Somme was cold, but may indicate instead that these animals, whose natural habitat was near the front of the ice, at certain times roamed southward and mingled with warm temperate animals. That the climate in northern France was arid at times is proved by the presence of layers of wind-blown dust or loess, which cover the terraces of the rivers of northern France, southern Germany, and Austria.

Mousterian Epoch.—Because of the colder climate of the Mousterian epoch the folk of that time were forced to spend a portion of the year in caves and rock shelters; for this

reason their implements, hearths, remains of feasts, and their skeletons are preserved in much greater abundance and perfection than are those of the men of the preceding epochs. During the warm summer months they lived in the open country, as is shown by the occurrence of their implements in loess (dust) deposits and river gravels. Their remains occur in many places in Europe south of Scandinavia, the latter country being largely covered by the ice sheet of the fourth glaciation. Asia Minor also contains deposits of this epoch.

The name Mousterian was given to this epoch because of deposits found in the floor of a cave and under the cliff in front of it, at Le Moustier, on the Vézère River in south-western France. There seems to have been a continuous residence in this cave during upper and middle Mousterian times and also during a part of the following (Aurignacean) epoch.

The Mousterian stone implements are modifications of those of the Acheulean but are superior in workmanship, variety, and design, and they were evidently made by the lineal descendants of the makers of the Acheulean implements. A change to a colder climate seems to have been the compelling cause for the improvement in the implements and the explanation for the little progress in the manufacture of stone tools in Acheulean times is ascribed to the sub-tropical climate which offered little incentive to exertion. When the climate became colder Mousterian man was compelled to leave the open country and seek such natural shelter as he could find, and so became a cave-dweller, a troglodyte. He was compelled to provide his body with some kind of clothing or freeze; the easily gathered and abundant fruits no longer supplied him with food and he was forced to hunt and having secured flesh to cook it. Necessity then required him to make tools of new design and better construction and some form of social organization must have arisen as the result of the living in caves. The *coup-de-poing*, or hand-stone, was still used, but this "all around" tool was gradually supplanted by implements designed for special purposes. A new method of manufacture, called the Levallois flaking, soon caused the disappearance of the *coup-de-poing*, because implements made in this way were lighter, had better cutting edges, were made with less labor, and served equally well many of the purposes of the older implement. The Acheuleans shaped the *coups-de-poing* from a nodule of flint by chipping off bits with a hammer stone until the desired form was obtained, but they had also learned to make the Levallois flake which was produced by breaking off a large flake so as to form one smooth, slightly convex surface. In preparing a nodule from which to manufacture the Levallois flake, the nodule was first dressed to the desired shape; then with a sharp blow a flake was detached which was later trimmed to final form. In Mousterian times this method of manufacture was perfected and Levallois flakes six to seven inches long and two inches wide were made. From similar flakes a variety of implements were made; one of these, the Mousterian point, rarely four inches long, was carefully retouched so as to form a sharp point. The Mousterian point was probably used for cutting, piercing, and scraping hides. Scrap-

ers of various kinds, awls and, for the first time, lance heads were also made. Spherical balls of limestone have been found which were probably used for bolas. Crudely made bone implements seem to have been manufactured in this epoch, but they are little more than bone fragments whose accidental shapes were useful.

A number of fragmentary skeletons of the makers of Mousterian implements have been unearthed and it is now possible to give an accurate description of the men of that time. The race is called the Neanderthal Race from a cave in a small valley of that name near Düsseldorf, Germany, where a skull of this race was unearthed. Remains of Mousterian men from at least 20 localities have been identified. These skeletons are all of men of one type; with large, broad, flat heads and strong jaws and teeth. (See MAN, PREHISTORIC RACES OF). The remains of Neanderthal men have been found only in caves but their implements have been discovered in terrace deposits indicating that they lived in the open during favorable weather.

The animals most characteristic of the Mousterian epoch are the mammoth, woolly rhinoceros, and the reindeer. The long hair which reached almost to the ground and the thick, soft, under-coating of fur shows that the mammoth was well adapted for a severe climate. (The food found in the stomach and mouth of frozen Siberian mammoths consisted of grasses, sedges, beans, and arctic crow-foot. In the winter the leaves and branches of small trees and shrubs were also eaten). The woolly rhinoceros (*R. trichorhinus*) was also protected by long hair and a thick under coating of fur. Besides these larger animals there were arctic foxes and hares, the banded lemmings and others. The occasional discovery of the remains of the straight-tusked elephant and Merck's rhinoceros indicates that either in the warm summer months or during intervals of warmer climate these southern animals migrated into Europe from the south.

The evidence from the character of the fauna and floras as well as the fact that man lived in caves instead of in the open during the greater part of the Mousterian, points to a severe climate which forced man from the open plains to such natural shelter as he could find.

The best evidence at present indicates the fourth glacial stage as the time in which the Moustereans lived. It is estimated that the Mousterian epoch lasted about 30,000 years and closed about 25,000 years ago (Osborn).

Geography.—The geography of Europe during Mousterian times differed somewhat from that of to-day. Scandinavia was covered with an ice sheet which extended a short distance south of the Baltic Sea, and England, for a time at least, was joined to France.

Aurignacean Epoch.—The older Paleolithic includes the pre-Chellean, Chellean, Acheuleans and Mousterian, and is succeeded by the younger Paleolithic, of which the first epoch is the Aurignacean. With the older Paleolithic, the Neanderthal race disappears and a new race or races of men appear, differing from it in physical appearance almost as much as the Neanderthals differed from the ape-man. The kinds of animals, however, remain nearly the

same, although their relative abundance varies somewhat at different times. The reindeer was common and because of its constant association with the remains and implements of younger Paleolithic man this division is often termed "the Reindeer Period." The horse, bison, cave bear, and cave lion, as well as other animals, were also living in the regions occupied by man in Europe. In Italy the Aurignacean seems to have been the only younger Paleolithic culture.

The love of personal adornment is shown in the perforated sea shells and back bones of fishes for use in necklaces, perforated teeth of various animals and beads made from ivory and reindeer horns which he wore. Bone tubes which served as flasks for pigment were made from the cannon bones of the reindeer.

Aurignacean man was the first to use bone to any great extent for making tools. From this material he made such implements as pins, chisels, and shaft-straighteners (first called *baton de commandements*). With him art seems to have had its beginning.

There was a marked improvement in the workmanship of the flint implements of this stage. One important flint was the graver (burin) used for making incisions in hard materials, such as stone, bone, horns, and ivory. Side scrapers (*racloirs*), end-scrapers (*grattoir*), flints shaped like a knife blade (*châtelperron-point*), spoke-shaves and tools of other designs were made. Figures in outline of horses, bison, rhinoceroses, elephants, stags and oxen represent crude attempts at art, but in some specimens the drawing is excellent.

During Aurignacean times the English Channel was not in existence and man could walk from France to England or Ireland without crossing any natural barrier, other than rivers. The Baltic Sea was reduced to a fresh water lake. During this epoch the climate in western Europe became dryer and less severe than it was in Mousterian times as is shown by deposits of loess.

Horses were abundant and were killed and eaten but, as far as known, they were never domesticated. Around one Aurignacean camp (Solutré) the bones of not less than 100,000 horses have been found. In this bone breccia remains of the reindeer and mammoth have also been unearthed.

The superb Cro-Magnon race appeared at the beginning of the Aurignacean and at about the same time the Neanderthals disappeared. It is probable therefore that the extermination of the latter was brought about by these new arrivals. Skeletons of the Cro-Magnon race have been found in France, Wales, Italy, Spain, and Austria. They were very tall men with an average height of six feet one and one-half inches and their brain capacity was larger than that of modern man.

Solutrean Epoch.—The Solutrean industry has an unexpected distribution in that it is not found in the lands bordering the Mediterranean. The artifacts of the epoch have, however, been found in England, France, Germany, Hungary, Bohemia, and Poland.

The Solutrean epoch is characterized by extraordinary skill in the manufacture of flint implements. At no other time in the Paleolithic was the fashioning of implements from flint so admirable. The most perfect of these

flints are laurel-leaf and willow-leaf spear heads. These implements are evenly flat and remarkably thin, so thin in some specimens as to be translucent; but the character which especially distinguishes them is the beauty of the secondary flaking (Solutrean retouch). In this process thin flakes were split off with great regularity, leaving long, shallow furrows which run from the edge of the implements up toward the middle; both sides of the laurel-leaf points have been dressed all over in this way.

Art which had such a promising beginning in the Aurignacean epoch was at a standstill, or even declined during the Solutrean epoch. The use of bone and ivory, however, continued, and bone and ivory arrow straighteners, spear points, awls, the first bone needles, and some primitive drawings and statuettes were made. The frequent occurrence among their remains of lumps of ochre and graphite shows that colors were used either for personal adornment, as was customary with the American Indians, or for paintings on the walls of caves. The sudden appearance of implements with the "Solutrean retouch" suggests that possibly a new race had invaded Europe. That this is probable is further shown by the discovery of a few skeletons (Brünn race) whose skulls are different from those of the Cro-Magnon race, and which are of as low a racial type as that of the Australian negroes. The skulls are unusually long for their width. This race did not drive out the Cro-Magnon race, but lived in Europe at the same time and from it the Cro-Magnons appear to have learned how to manufacture the beautiful Solutrean spear-heads. One possible cause for the lack of progress of art during this epoch is the slight amelioration of the climate which permitted man to live in the open, and, consequently, the incentive of the cave dweller for drawing and carving was lacking.

Magdalenian Epoch.—The culture of the people of the Magdalenian is so unlike that of the preceding epoch that it is difficult to understand how the high art of this epoch could have been made by descendants of the Solutreans. Instead of beautifully made flint implements, the inhabitants of the Magdalenian caves manufactured stone implements of inferior workmanship and often of poorly selected stone. But the lack of a highly developed flint industry was fully compensated for by tools made of bone, horn, and ivory. A great variety of new kinds of tools and ornaments of bone was soon invented and the skill in the manufacture of bone is as surprising as the lack of skill in the working of flints. In the early Magdalenian the bone implements were similar and less varied than later in the epoch. The bone implements most commonly found are spear-heads, which at first were without barbs, but later were made with a double row; bone spear throwers, shaft straighteners, and bone fish hooks. Bone needles were beautifully made and were much superior to those of later times. "The Romans, for example, never had needles comparable to those of the Magdalenian epoch." (Lartet).

The art of Magdalenian times attained a high degree of development. This is seen in carvings of animals on bone and ivory; in engravings on bone, on slabs of stone, and especially on the walls of caves and rock shelters.

The culmination of Magdalenian art is probably that found on the roof of the cave of Altamira in northern Spain, where a large number of figures, some of which are of life size, colored in black, red, yellow, and polychrome, representing bison, horses, deer, and other animals are found. The drawing is of a high order and could not have been executed by any but skilled artists.

It is probable that the Cro-Magnon race was the dominant one during the Magdalenian epoch, and that they were the artists of this time. More than 30 kinds of animals were portrayed by the artists and sculptors of this epoch and it is not surprising, perhaps, that the more impressive of them, such as the mammoth and bison—though perhaps not the most abundant—were favorite subjects. Besides these animals they drew or engraved the outlines of the rhinoceros, the horse, the ibex, the lion, the bear, and the deer. A few figures of women have been discovered but figures of men were rarely and crudely portrayed.

Azilian Epoch.—The Paleolithic period closed with the Azilian epoch. Instead of a form of art higher than that of the Magdalenian, better carvings, and tools of superior workmanship, such as one would expect, there is a deterioration in art and flint working. "With the advent of Azilian the realistic art of the Magdalenians disappeared and is succeeded by rude attempts at geometrical or generalized representations. There is no working in ivory; this material has disappeared with the mammoth, and stag's horns take its place" (Sollas).

Numerous pebbles have been discovered which are painted on one side with various designs; dots, parallel lines, ladder-like patterns, forms which resemble the capital letters F, E, I, and other designs. What these symbols signify is not known.

The cause of the abrupt change in culture between the Magdalenian and Azilian, which has been characterized as a revolution rather than a development, is explained on two theories. The discovery in the deposits of the epoch of skulls of two different types, one extremely long headed and the other extremely short headed, is considered to indicate the possibility that the Azilian culture was introduced by new races and was not a development from pre-existing European cultures. It is also suggested that the Azilians no longer lived in caves but in the open country and that, consequently, art practically disappeared. Moreover, the disappearance of the mammoth and reindeer from Central Europe cut off the supply of ivory and reindeer horns and man was forced to use the greatly inferior stag horns for making harpoons and tools. Azilian men, like their predecessors, knew nothing of pottery and they had no domesticated animals or plants.

The Azilian epoch seems to have occurred at the very close of the last Glacial Stage as is shown by the absence south of Belgium of the reindeer, arctic fox, and arctic hare. The common animals were those of the present day, such as wild boar, wild cattle, roe deer, rabbit, brown bear, and field mouse. The Azilian culture had a wide distribution in Europe and has been identified in Scotland, England, France, Germany, Austria, and Spain. The

Paleolithic is believed to have closed 7,000 to 10,000 years ago and was followed by the Neolithic period (q.v.).

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PALEOLOGUE, pa'lā'ō'lōg', Maurice, French diplomat and author: b. Paris, 1859. He was employed in various capacities in the Department of Foreign Affairs and was sent on diplomatic missions to Bulgaria, China, Korea and other countries. He has written several works mostly dealing with literature. They include 'L'art chinois' (1888); 'Vauvenargues' (1889); 'Alfred de Vigny' (1892; 3d ed., 1908); 'Profils de femmes' (1895); 'Sur les ruines' (1897); 'Le cilice' (1901); 'Rome, impressions d'histoire et d'art' (1902); 'La cravache' (1904); 'Le point d'honneur' (1907); 'Dante son caractère et son génie' (1909).

PALEOMASTODON, a genus of primitive elephants fossil in the lower Oligocene beds of the Fayoum, Egypt. The species varied in size from that of a tapir to that of a half-grown elephant and their frames and limbs were rather lightly built. The reduction of the dentition and certain other features point to still more primitive ancestors. The neck was relatively long, the skull long and narrow, having a high and crested occiput, and the front projecting into a long snout. Both jaws contained short, partly enameled tusks, those of the upper jaw curving downward somewhat divergently, and those of the lower jaw pointing straight forward.

PALEOMETEOROLOGY. See PALEOCLIMATOLOGY.

PALEONTOLOGY, the science of the ancient life that inhabited the earth during the vast periods of time which have antedated the age of man. This science dates back only to the beginning of the 19th century, when William Smith, Cuvier, Brongniart, Lamarck, Blumenbach and Schlotheim initiated the study of fossil life as a distinct branch of scientific research. It was christened "palæontology" by de Blainville and Fisher von Waldheim in 1834. Erroneous and fantastic ideas regarding the nature and origin of organic fossils had prevailed till the last decade of the 18th century, interesting accounts of which, as well as of the later history of the science, may be read in the

acter were incorporated into Neo-Pythagoreanism. These were conjoined with a strong ascetic trend, based apparently on the ethical dualism, yet reminiscent of the Stoic-Cynic tradition. Consult Zeller, 'Die Philosophie der Griechen' (Leipzig 1880-81); Vacherot, 'Histoire critique de l'Ecole d'Alexandrie' (Paris 1846-51).

NEOCENE, in geology, a term used by the United States Geological Survey to include what Lyell called the Miocene and Pliocene periods. The word means "new (or late) recent," and is contrasted with Eocene, "dawn (or early) recent." See TERTIARY.

NEOCOMIAN (Lat. *Neocomum*, Neuchâtel), in geology, a term applied to the lowest marine stages of the Cretaceous system, because of its typical occurrence at Neuchâtel in Switzerland. There and in southern France this formation, consisting of limestones and marls, is as much as 1,600 feet thick. The term corresponds to the English Wealden and lower greensand, and to the German Hils; is little used in America, and in France is used broadly and strictly, Neocomian in the wider sense including the stricter Neocomian (made up of Hauterivian and Valanginian), as well as Barremian and Aptian. Consult Pavlow, *Quarterly Journal London Geological Society* (Vol. LIII, 1896).

NEODYMIUM, in chemistry, an element whose existence as a constituent of didymium (q.v.) was recognized by Auer von Welsbach. It occurs in cerite. It has the chemical symbol Nd and an atomic weight of 144.3, and is distinguished from other constituents of didymium by yielding rose-colored salts. Its oxide has the formula Nd_2O_3 . Pure neodymium salts were first obtained by Demarcay in 1898. Metallic neodymium melts at $840^{\circ}C$, has a specific gravity of 6.9, and decomposes water slowly when cold and rapidly at the boiling point. Its properties are much like those of cerium (q.v.). Consult Kellermann, 'Die Ceritmetalle und ihre prophore Legierungen' (Halle 1912).

NEOGENE (Greek, "late-born," "late"), in geology, a term used by Continental geologists to include the Lyellian Pliocene and Miocene, that is corresponding with Neocene (q.v.), as used by the United States Geological Survey.

NEOHIPPARION, a genus of primitive horses found fossil in the Upper Miocene and Lower Pliocene of the western United States. Complete skeletons have been obtained, and show this horse to have been a small pony with slender deerlike legs and three functional toes. It was probably the earliest kind of horse adapted to a grazing life in a desert region, and appears to have been very numerous and represented by two or more species.

NEOLITHIC PERIOD, The. The Neolithic (Greek *neos*, recent, and *lithos*, stone) Period was so named because in it man ground some of his stone tools, especially the celt or ax, whereas, Paleolithic man made only chipped implements. More important differences than these, however, distinguish the cultures of the two periods. Paleolithic man was a hunter and knew nothing of agriculture; he had no domesticated animals, not even a dog; he had not

learned to make pottery and, consequently, cooking as an art had not been acquired. Early in the Neolithic Period, on the other hand, man had domesticated the dog, cow, sheep, pig, horse and goat; he planted and harvested grains of various sorts; he had learned to spin and weave and make pottery.

Transition between the Paleolithic and Neolithic.—The meaning of the rather sharp break between the Paleolithic and Neolithic has given rise to much discussion. With the evidence now at hand one can do little more than speculate on the reasons for the seemingly sudden change in Europe from the old to the new. As the climate of Europe changed and the animals which Paleolithic man hunted disappeared, and as the population became too dense for the supply of food obtained by the chase, other means of securing food necessarily would be sought. Edible seeds would be gathered and stored and some of these, scattered by chance, would grow and methods of cultivating them would speedily be devised. The domestication of animals was probably brought about by rearing the captured young of wild animals such as the sheep and goat, some of which were kept until grown and offspring born. The new requirements of a more sedentary life which would result from this readjustment would lead to the invention of new tools, or the better finish of old ones, and it is not surprising that Neolithic man early learned to grind and polish the edges of his stone axes. There is little evidence that the higher civilization of the Neolithic was developed in Europe, but rather it is probable that tribes of Neolithic people who had made progress in some other continent migrated to Europe and either absorbed the Paleolithic inhabitants or destroyed them. If the Paleolithic inhabitants were absorbed peacefully by the new immigrants, the amalgamated population would necessarily adopt the mode of living best suited to the altered conditions of the environment, i.e., Neolithic methods. "The gradual disappearance of the reindeer and other mammalia would henceforth necessitate a complete change in their manner of living. The nomadic hunter would soon sink into the herdsman, and the mechanic would readily lay aside his roughly chipped tools for those with finely ground and polished edges. On the other hand, should a few cave shelters in one or two favorite localities continue to be inhabited after the arrival of the Neolithic tribes on the scene there might be few traces of amalgamation to be found." (Munro). It is evident that the newcomers would learn something from the inhabitants among whom they settled and that certain of their tools and methods of making tools would be acquired and retained in the new civilization.

Some authorities hold that the last phase of the Paleolithic, the Azilian (see PALEOLITHIC PERIOD), nearly bridges the gap between the two periods. If the inhabitants of Maglemose (Great Peat Bog) on the Island of Zealand, Denmark, were Paleolithic people the gap is even more nearly filled. This station is a peat bog several hundred yards from the old shore of a lake which, on geological grounds as well as on the evidence of the flora and fauna, is shown to be older than the kitchen middens or shell heaps, which are generally considered to

be the oldest works of Neolithic man. One remarkable feature of the Maglemose remains is that the huts of the people were built on a huge raft or floating island. Many chipped flint implements have been found but none showing any trace of polish. No pottery has been discovered but many objects made of bone and staghorn, such as daggers, fish-hooks and harpoons.

Kitchen Middens or Shell Heaps.—It is generally agreed that the shell refuse heaps, so well preserved in Denmark, were made by man near the beginning of Neolithic times. Some of the kitchen middens are as much as 10 feet thick, more than 900 feet long, and from 100 to 200 feet wide. They are composed almost wholly of shells, with a few bones of fishes, birds and mammals, some fragments of pottery and a few flint implements. Everything in the heaps was brought to the spot by man. The most abundant species of shell-fish in the mounds are the oyster, the cockle (*Cardium edule*), the mussel (*Mytilus edulis*), and the periwinkle (*Littorina littorea*). Of these shell fish the oyster has disappeared from the neighboring waters, and the cockle and periwinkle are much reduced in size. Among the bones of wild birds which occur are those of the duck, goose and wild swan. The fact that the wild swan visits Denmark only in the winter is probably evidence that these ancient Neolithic fishermen did not migrate from one part of the country to the other at different seasons.

The flint implements of the kitchen middens consist of long flakes, 8-13 inches in length, some of which were used for knives; triangular axes, none of which are ground on the edges, awls and the so-called pick. Bone and horn tools, and, for the first time in man's prehistory, fragments of pottery also occur. The making of pottery was a momentous discovery for primitive man, since by its use he was enabled to cook a greater variety of foods and to render others more digestible and palatable. It is to be noted that polished flints are absent in these early Neolithic deposits. Sites of huts inland have also yielded potsherds and unpolished stone implements but no polished flints. The similarity of some of the tools to those of the kitchen middens indicates that these remains are of the same age. The term Campignian has been given to these remains, which are probably contemporaneous with the Kitchen Middens.

Lake Dwellings.—During the greater part of the Neolithic Period huts erected on piles driven into the mud of the shallow waters of the larger lakes of Switzerland were inhabited by man. The lake villages were connected with the shores by draw bridges and the inhabitants used large canoes dug from trunks of big oak trees. Lake dwellings were more common in Switzerland than in other parts of Europe, but Neolithic man also built them in Denmark, Austria, and other countries. Lake dwellings were also used in Europe by men of the Bronze Age, and even at the present time houses built on piles driven into the mud of lakes and other bodies of water are occupied by the natives on the estuaries of the Amazon and Orinoco rivers by natives of New Guinea, Central Africa, Borneo and elsewhere.

A great deal is known of the life of the

Neolithic lake dwellers because of the excellent preservation of their implements and household utensils in the mud and peat of the lake bottoms, where they fell after the destruction of the dwellings by fire or where they were lost or thrown from the platforms upon which the wattled huts were built. Stone axes with wood or staghorn handles, arrowheads, barbed harpoons of staghorn, fish hooks and needles of bone, and wooden utensils such as tubs, spoons, and plates have been unearthed. Cloth was made of wool and flax, and fish nets and fish lines of flax.

The pottery shows that the lake dwellers made utensils of clay of sufficiently good quality to withstand fire as is indicated by the soot which still coats the bottoms of some of them.

The lake dwellers cultivated wheat, barley, millet, and flax as is shown by the presence of these cereals in the mud among the piles. Loaves or cakes of unleavened bread made from wheat and millet have been discovered, and show the approach to a modern mode of life. Stable refuse on the lake bottoms beneath the ancient huts indicates that horses, sheep and cattle were domesticated and were stabled in the lake dwellings. The advantage of lake dwellings to Neolithic man consisted largely in the protection they afforded to their possessors because of their easily defended positions.

Burials.—The Neolithic people honored some of their dead by burying them with their most precious possessions under mounds of earth or stone, called barrows or tumuli. In Great Britain some of the barrows are 200-400 feet long and 60-80 feet wide and generally contain one or more chambers constructed of huge slabs of stone. In Great Britain there are two forms of the barrow, the long barrows which contain skeletons with long-headed or dolichocephalic skulls, and the round barrows which contain short-headed or brachycephalic skulls. Some barrows contain a single skeleton whereas others were family or tribal cemeteries. In Denmark a single tumulus contained 70 burnt interments. Tumuli were also erected in the Bronze Age and many beautiful bronze implements have been discovered in them.

Dolmens are structures formed by great stone slabs set on edge and capped with one or more slabs forming a table-like structure. The size of some of these roof stones and the difficulty of placing them in position is realized when it is known that some of them weigh as much as 40 tons. Some of the dolmens were formerly covered with earth and stones which have since been removed either by man or by the natural process of erosion.

Classification.—An entirely satisfactory classification of the Neolithic in Europe has not yet been made, but that of Montelius for Sweden seems to be well established. It is based on the variations in form of the chipped and polished axe heads or celts which were gradually evolved or introduced and upon geological evidence. Beginning with the most recent deposits the classification is as follows:

Stage IV (Youngest). Axes of the thick or broad-headed type with relatively flat sides and nearly square cross-section at about the middle. Axes with shaft holes. Exquisitely chipped, broad-bladed, flint daggers with a narrower portion for a handle. In some places the burials were in stone cists.

Stage III. Axes about the same as in Stage IV. Narrow-bladed flint daggers of beautiful workmanship. Graves with covered passages.

Stage II. Axes of the small or thin-necked type, almost rectangular in form and with strongly arched sides and square angles. Age of Dolmens.

Stage I (Next to Campignian and Kitchen Middens in age). Axes of the pointed-necked type, either rough hewn or polished. Triangular in cross-section.

Climate and Geography.—The climate of Switzerland during Neolithic times seems to have been nearly, if not quite, as it is now as is shown by the seeds and fruits which have been preserved in the mud and peat under the lake dwellings. The wild species do not differ from similar species in the same region to-day and the cultivated grains are unlike those now grown in Switzerland in size only. The larger size of our cultivated cereals is doubtless the result of many years of selection.

The physical geography of Europe during Neolithic times did not differ greatly from that of to-day. Great Britain was separated from Europe by the English Channel as it is now. The fact that the cockles, mussels and periwinkles of the shell heaps of Denmark are of full ocean size whereas those of the present Baltic are only about one-third the normal size is proof that the water has been freshened since then and indicates that the connection between that sea and the ocean has been decreased in width or depth by the elevation of the bottom and land near its entrance to the Atlantic. Raised beaches also prove that the coast of southern Norway has been raised about 225 feet since the beginning of the Neolithic Period. As one passes south along the coast of Denmark the Kitchen Middens gradually approach the sea-level until in southern Jutland and Schleswig-Holstein they disappear altogether and are not found again until the coast of Belgium is reached. It is probable that men made Kitchen Middens along the shores south of Denmark, but that a lowering of the land has caused them to be covered with water. This belief is confirmed by the dredging of implements of Campignian Age near Koldin at a depth of 10 or 12 feet. Notwithstanding these minor differences the climate and geography of Europe during the Neolithic was very similar to those of the present.

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NEON. See LIQUEFIED AND COMPRESSED GASES.

NEOPHYTE (Greek, "newly planted or grafted on"), originally applied to those newly initiated into the Eleusinian or other ancient Greek mysteries, of whom Plato says "there are many wand bearers (the wand being the badge of the initiated) but few mystics." The catechumens who had been just baptized were so styled in the early Church. These newly made Christians were considered less likely to stand firm against paganism than their older and more experienced brethren. Hence the term was slightly tinged with disparagement. Saint Paul forbade the ordination of the neophyte or novice (1 Tim. iii, 6), and the 3d Council of Arles (524) decreed that a year's probation was necessary for candidates for holy orders among the newly baptized. Yet Ambrose was elected bishop of Milan (374) when he was but a catechumen and was consecrated soon after his baptism. Newly converted pagans or disbelievers are still styled neophytes by Roman Catholic missionaries and Gregory XIII established a college at Rome (1622), the Propaganda, in which they might be educated and trained to preach to and convert the people of their own land.

NEOPLASMS. See TUMOR.

NEOPTOLEMUS, nē-ōp'tōl'ē-mūs (also called PYRRHUS), in Greek legend, the son of Achilles and Deidamia. Taken to Troy by Odysseus, he was one of the band who captured the city by means of the wooden horse. He slew Priam and took to himself Andromache, the wife of Hector. He afterward went to Epirus, where he married Hermione, in consequence of which Orestes, her former lover, killed him at Delphi.

NEORNITHES, nē-ōr'ni-thēz, or **EUORNITHES**, a sub-class of the class *Aves* (birds) embracing all known birds, fossil or recent, since the Jurassic Period, as distinguished from another sub-class *Archæornithes*, which contains, so far as yet known, only the archæopteryx (q.v.). The sub-class *Neornithes* may be divided into three sub-divisions, namely, (1) *Ratitæ*; (2) *Odontolæ*; (3) *Carinata*.

NEOSHO, nē-ō'shō, Mo., city, county-seat of Newton County, on the Kansas City Southern, the Missouri and Northern Arkansas and the Saint Louis and San Francisco railroads, about 170 miles southwest of Jefferson City and 140 miles south by east of Kansas City. It was settled in 1839; in 1868 was incorporated as a town and received its city charter in 1878. It is near the lead and zinc mining region of Missouri. The chief manufacturing establishments are machine-shops, flour mills, foundry, agricultural implement works, repair shops and furniture factory. There is located here a government fish hatchery which occupies 34 ponds. It is the seat of the Scarritt Collegiate Institute (M. E. South) and has a high school, elementary schools and a public school library. The city owns and operates the water-supply system. Pop. 3,661.

NEOSHO, a river which has its rise in Morris County, Kan., in the central part of the State. Some of the small streams which form the head-waters have their sources near short streams that flow north into the Kansas River.

Cleland, H. F.

1920

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THE SOCIETY OF THE FUTURE

A Forecast from a New Angle

BY HERDMAN F. CLELAND

FOR millions of years to come the earth will probably be suitable for the habitation of the human race. Such are the conclusions that have been reached by a careful analysis of the past as revealed by a study of the rocks and their contained fossils, and by the researches of astronomers. This belief rests upon the facts that for many millions of years the earth has been inhabited by animals that have required the same environment as man; that there is no reason to believe that the sun's heat will materially decrease for eons to come; or that the earth will be burned by collision with some great star. However, during the vast geological ages the climates were not congenial at all times nor in all places. During some periods the seas of the world were smaller than now and the continents were larger and great deserts occupied them; during others the seas spread over thousands of square miles of the continents and moist climates were nearly universal; during still others great ice sheets moved over the lands but did not cover the entire world. It has even been suggested that we are now in an interglacial stage, and that glaciers may again move south in North America and Europe, possibly to reach the Ohio River as they once did.

Notwithstanding such vicissitudes; notwithstanding the fact that at times life was nearly wiped out and whole races of animals and plants became extinct, always some survived and from some of these sprang the life of to-day. No place in the world was continuously habitable during the world's history but always some places, now here and now there, were suitable for life, and it is probable that for untold centuries in the future similar conditions will prevail.

There is at least one serious element of doubt in all forecasts of the duration of the human race: geological history

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records, that without apparent cause, races that had lived on a continent and had had their entire evolution there suddenly disappeared, leaving no record except that afforded by their broken and fossilized bones. The horse and camel races are examples. They lived and evolved in North America from small, five-toed creatures to nearly their present forms, and then with apparent suddenness became extinct. But the same regions which formerly supported great herds of these animals are now as favorable for their growth and increase as any place on earth. Their extinction on the Western Hemisphere was due, with little doubt, to epidemics, and if the human race vanishes during the next 1,000,000 years its disappearance will doubtless be brought about by some epidemic or epidemics and not through a great change in climate or other physical conditions. The progress of medical science and bacteriology would seem to make such a fate unlikely. Moreover, man lives under more diverse conditions and over a greater part of the world than any other animal of the past or present and it is probable, therefore, that in some place or places he will find a refuge from any disease.

One may, then, with reason, assume that man will continue to populate the earth for many hundreds of thousands of years to come. If this is true it is interesting to speculate on the kind of creature the man of the distant future will be. Would you, were you to return to the earth in the year 1,001,920, be able to recognize your descendants as human beings, or would you find them so modified that they would appear to be, or would be in fact, a higher or lower race? Geology, or more strictly paleontology, affords many examples of animals that existed a million or more years ago which are nearly identical with their living descendants. There is a small lizard living in New Zealand today which is the little-changed descendant of one that lived in Permian times, a period so remote that at least 10,000,000 years have lapsed since then. The tapir of the Amazon forests could not be distinguished by the casual observer from an ancestor that lived 3,000,000 years ago. The turtle, one of the strangest animals of the geologic past and of the present, had the same architecture when the earth was 9,000,000 of years younger than it is now. Man, like these animals, seems to have reached the climax of his evolution, if indeed, he has not passed it and is not now retrogressing.

Some of the men (Cro Magnon) of the Old Stone Age (Paleolithic) had large, finely-moulded heads and splendid bodies and were, as far as one can judge from their skeletons, one of the finest races the world has seen, and yet, at a conservative estimate, these men lived 16,000 to 20,000 years ago.

Granted then, that there is likely to be little physical improvement in the human race if Nature is not interfered with (although this cannot be proved), is there also a limit to the development of the intellectual and rational powers of man? It is generally assumed that there is none, but this supposition is not supported by evidence, although it cannot be disproved. Fortunately, much is known about the early Greeks; their bodily form is shown in their works of art; the quality of their intellect is revealed in their writings; and their technical skill is indelibly recorded in their architecture and sculpture. In all of these qualities they have never been surpassed. As far as one can judge from their writings, no philosophers with greater intellectual powers than Plato and Socrates have yet appeared. When the appliances at his disposal are considered, Aristotle ranks as one of the world's greatest scientists, as well as a great philosopher. These men lived 2,000 years ago,—a short time geologically,—but in these twenty centuries no advance in intellectual power appears to have been made.

What will be the effect of philanthropy as now practiced, upon the physical and mental betterment of the race? With the progress of science and the spread of a spirit of altruism the law of natural selection,—the elimination of the physically and mentally unfit,—has already, in large measure, ceased to be operative in many countries and the result in many European countries and in our own is that the offspring of mentally and physically imperfect persons pass their inferior qualities to their descendants and thus prevent racial improvement, if, indeed, they are not causing the deterioration of the race.

Physical and mental improvement in the past was brought about largely by adverse conditions. The horse would not have been "one of the most perfect pieces of machinery in the living world," so superb that it can be said that among the works of human ingenuity "there is no locomotive so perfectly adapted to its purpose, doing so much work with so small a quantity of fuel as this machine

of nature's manufacture," if it were not for its untold centuries of struggle against increasing aridity and a changing vegetation. The death rate must frequently have been enormous and doubtless many times the race was on the verge of extinction; but this mortality was greatest among those whose structure was less suited for the new conditions or whose brain failed to increase in size and power. If during these long years those horses that lacked the qualities which best suited them for their environment, or whose qualities were below the average, had been preserved,—as the unfit of the human race are being saved today,—they would have diluted the blood of those best suited to survive, and the horse, as we now know it, would not have been evolved, but instead, the race would doubtless have become extinct. In the past, easy conditions have not, in general, resulted in progressive change to a higher type.

An interesting example of the effect of hard conditions on man can be gleaned from two reports that have recently appeared. The report of the Surgeon General of the U. S. Army on the results of the physical examination of the drafted soldiers shows that the negroes in the United States Army were, on the average, physically superior to the white soldiers, and that they were also less subject to bacterial diseases. The second report is one from New York City on the living conditions of several thousand families. This investigation shows that the mortality among negro children is much greater than among those of any other class in the city.

Other reports show that in 1916 the mortality of negroes to whites in cities was as 5 to 3. These apparently contradictory reports are really in accord. Because of the unsanitary conditions under which the negroes usually live, the weaker negro children have little chance of reaching maturity and, as a consequence, it is in general only the best physical specimens that rear families. The effect of this selection is seen in the fine physique of the American negroes. Another example points to the same conclusion: the Jewish race for hundreds of years has been compelled to live in unhygienic environments and under unfavorable economic conditions. An indirect effect has been a virile race which, when transplanted to such genial surroundings as are found in America, soon developed leaders in many lines of financial and intellectual endeavor.

As has been stated, evolution has progressed most rapidly and effectively under hard conditions. Geological history teaches us an obvious lesson in the present crisis. Now that the World War is over and the peoples of Europe are suffering for the want of sufficient clothing and food, and will lack much that before the war they thought to be the necessities of life, we must not conclude that the future generations of the people who are enduring these hardships will be less sturdy mentally or physically than those who were born in lands that were not so devastated or impoverished. On the contrary, the qualities which will be developed by the adverse conditions under which they will live may make them masters of the people of the Americas who are now living at ease, and who are not being driven by necessity to improve. The Japanese in America afford a striking illustration. This race is able to replace the whites in the agricultural districts of California because, during a struggle of hundreds of years, the Japanese have become enured by severe competition and have learned to live comfortably on food and in habitations that Americans and Canadians consider inadequate.

One can hardly err in prophesying that the Malthusean law which states that the race will increase numerically faster than the means of subsistence, will not be operative. Attention has repeatedly been called to the small families of the educated. Large families in the United States, France, and Great Britain are rare, except among the ignorant. The large family in Germany was encouraged for the obvious reason that the greater the number of sons the greater the power of the military. In the not distant future, possibly before the food supply is inadequate, laws will be enacted to prevent too large families, if indeed such laws will be necessary.

The problem of race: the feeling of superiority of the white race for the yellow, of the yellow race for the white, and the red for the black, has been a source of trouble in the past and will continue to be one of the great problems of the near future. But will not the time come when races, as such, will cease to be? The American Indian in the United States affords an interesting proof. Some years ago measurements of the heads of Indians of Minnesota were made in order to determine which were of pure blood and which were not. It was found that about two-thirds of the

Indians of Minnesota contain white blood. The Indians on the reservations in New York State probably have more white than Indian blood in their veins.

Provincialism must necessarily become less and less pronounced as the peoples of different countries learn more and more about and mingle with the peoples of other countries. This was ordained when the steamboat, electricity, the aeroplane and other inventions brought the countries of the world together. One result of this closer contact which will accompany the elimination of space will be that the problems of each country will become the problems of the world.

This interdependence of peoples is already felt in ways that would have seemed impossible one hundred years ago. A few examples will suffice to illustrate this condition: a disaster to the Gloucester fishing fleet brings hardship to the Cubans who depend upon the cod of the Grand Banks for part of their food; a hurricane destroys the banana crop of Central America and causes real distress among the poor of New York and Boston; a severe drought in Argentine brings death to the great herds of cattle of that country and the prices of meat and shoes go up throughout the world; a prolonged strike in the woolen mills of England reduces the output of cloth, and the poor of France and Italy must suffer,—and so on.

The war has shown that even now no country is entirely independent. Moreover, who can doubt that even the disadvantages of climate and environment may, to a considerable degree, disappear as the result of mechanical appliances, just as in some of the cotton mills of Alabama the air is cooled in summer by ice machines and is provided with the amount of moisture required for the best weaving of the cloth.

The possibility of artificial selection must not be overlooked in any consideration of the future of the human race, for if mating is determined by the Government, the improvement of the race may be rapid and striking. All familiar with the great number and diverse varieties of pigeons, of dogs, of goats, of horses, of cattle, and of plants which have been produced, almost at will, by artificial selection will understand the possibilities of a great modification in the form, structure and intellectual power of our race if eugenics are compulsory and selections are

wisely made. One must curb the imagination when forecasting the outcome. If our social organization becomes as perfect as that of some insects, this will doubtless be done. Who knows what the functions of the State of the future may be? This is a great, unknown factor, but when the vast stretches of time during which the race will probably exist are considered, it does not require a vivid imagination to picture this human product of artificial selection as super-men and super-women. Without artificial selection, however, the man of the future will probably differ little from the people of our own time.

The geological history of ants offers a suggestion as to what may be in store for our descendants. Ants preserved in amber,—the fossilized gum of the pine in which they were entrapped in Oligocene times, perhaps three millions of years ago,—are said to be in all respects like the ants of today; their physical form cannot be distinguished from that of their modern relatives, and their social organization was so far advanced that the workers, the queens, and the males had the same characters as now. With the completion of mental and physical evolution the social evolution of the ants progressed until it went further than it has among human beings. (It is possible, however, that physical evolution came to an end because of their social habits). When carefully analyzed our present day civilization and social organization are seen to be in many respects,—some would say in most respects,—illogical, uneconomical, and unjust, and consequently unstable. The old order,—the product of individualism,—when every man works for himself and not for the State, is passing away and society is becoming adjusted to new and more permanent conditions.

What, then, will be the future of the human race? If, as has been suggested, one can find a parallel in the evolution of bees, ants, and other social insects, one gets a glimpse into the future; and if, as the history of other animals teaches, man has nearly or quite reached the limit of the mental and physical development of which he is capable by natural means, it seems inevitable that the future will be largely spent in perfecting his social organization. But before this adjustment can be completed many false steps will have been taken,—some so unfortunate that, for a time, the right road will have been lost,—but such errors, although destructive to many individuals and the

cause of untold sufferings, will be warnings to prevent similar mistakes. One can hazard the prophecy that at some time,—perhaps less remote than some of us think,—the individual will be an integral part of the social machine; that all will work for the common good; and that the food and the housing will be the same for all. In the bee-hive when the colony realizes that the drone is not necessary for its perpetuation he is driven away or is actually put to death, and this is also the fate of other individuals who are not contributing to the well-being of the colony. One wonders what will be the fate of the lazy, the vicious, the insane, and the permanently disabled in the human society of the future. However, one must not carry the parallel too far, for man is unique among animals in the high development of the brain.

But what will be the result if, in order still further to promote its efficiency, this society of the future regulates marriage so as to produce strains that will more effectively do its work? The possibilities are startling. As the great draft horse and slender race horse have been developed by careful selection, so one human strain might be developed for great physical strength, another for manual dexterity, and still another for intellectual power; of this last some would have an aptitude for invention, some for executive work, some for literature, and some for other lines of intellectual endeavor.

There seems no likelihood that this future society will be for the proletariat, as the Bolsheviki teach, nor, on the other hand, will it be for the bourgeoisie, but in this perfected organization search will doubtless be constantly made for talented men and women in order that all may profit by the work of genius. When one takes his mind from the things of the present and allows himself to think of the thousands and perhaps hundreds of thousands of years during which man will probably inhabit the earth, he realizes that the race is in the infancy of its social evolution, and he can form some feeble conception of what lies before it.

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**A PLEISTOCENE PENEPLAIN IN THE
COASTAL PLAIN**

HERDAN F. CLELAND

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A PLEISTOCENE PENEPLAIN IN THE COASTAL PLAIN

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The Black Belt of Alabama is famous throughout the state, and in the surrounding states, for its great fertility, its production of cotton and corn, the levelness of its plantations, the large proportion of negroes to whites, and its numerous ante-bellum mansions—the visible manifestations of its former wealth.

As one rides over the gently undulating surface of the region, with its deep black soil, and crosses the steep-sided gullies and the bluff-bordered rivers, he is impressed with the aspect of topographic youth. However, a more careful study in the field and of the geological literature forces one to the conclusion that the region is not in the youthful stage of a first cycle of erosion, nor in a mature stage of erosion, but that the surface is a recently raised plain, so flat as almost to make the term peneplain—almost a plain—inappropriate. The following excellent description will assist one in visualizing the region:

The surface of the country, underlaid by the Rotten Limestone, is but little diversified; it is, however, occasionally broken into rounded bald knolls, as may be seen between Arcola and Demopolis, and between Livingston and Sumterville. The summits of these hillocks are sometimes ornamented with cedars, but more frequently they are quite bare, or covered with but a scanty vegetation; even where the surface is but slightly undulating, bald spots occur where the naked rock has come up. But the most remarkable feature of this region is the extensive tracts of land covered with a deep, black soil of great depth and extraordinary fertility, which may be seen in various parts of Sumter, Greene, Marengo, Perry, and Dallas, but more particularly in the "cane brake." The surface of these remarkable tracts has barely sufficient inclination to admit of easy drainage, without giving the water force enough to remove the soil, so that, instead of excavating a channel at the bottom of the trough-like depressions where this sort of land occurs, it is absorbed by the soil, or spreads over a considerable space, where it loses all transporting power.

The unbroken surface of this region is due to the homogeneous character of the limestone, which suffers waste equally on this account, over considerable areas; and hence the entire absence of ravines, and other abrupt irregularities. . . . In the uncleared parts of the cane brake, . . . one can scarcely satisfy himself that he is not standing on the low grounds of a river; the deep, alluvial-looking soil beneath his feet, the moisture-loving long moss (*Tillandsia usneoides*) above his head, together with an undergrowth of Sabals, Palmettoes, and other natives of damp soils, strengthen the illusion.¹

Professor Eugene A. Smith's accurate and suggestive description is as follows:

The Selma chalk underlies a belt entering the State from Mississippi and extending eastward with an average width of 20 to 25 miles, to a short distance beyond Montgomery, where its distinctive characters are lost or merged into those of the "blue-marl region." . . . The somewhat uniform composition of the Selma chalk has caused it to be more deeply and evenly wasted by erosion and solution than the more sandy formations north and south of it. As a consequence, its outcrop is in the shape of a trough, with a gently undulating, almost unbroken surface except where remnants of the once continuous Lafayette mantle have protected the underlying limestone from erosion and have thus formed knobs and ridges capped with its loams and pebbles.

In this belt, more than in any other of the Coastal Plain, the soils show their residuary character. They are, as a rule, highly calcareous clays and, where much mixed with organic matters, of black color. Throughout this section are areas originally destitute of trees and hence known as "prairies." From the agricultural point of view, the Selma chalk or black belt is the most highly favored part of the State and, apart from the cities, holds the densest population.²

R. M. Harper³ characterizes the topography as "gently undulating in a manner difficult to describe, though probably due almost wholly to normal erosion processes," and points out that "some of the region, mostly remote from the rivers, is so level that the railroads have built straight tangents (i.e., straight tracks) a dozen or more miles in length." He also points out the rarity of swamps. The region is traversed by rivers that are, in most places, bordered by steep, bare bluffs—in some places 60 feet

¹ *Tuomey's Second Biennial Report*, pp. 134-37, 1848, quoted by Eugene A. Smith in his report on the *Geology of the Coastal Plain of Alabama* (1894), pp. 282-84.

² *Underground Water Resources of Alabama* (1907), p. 13.

³ Roland M. Harper, "Economic Botany of Alabama," *Geographical Report on Forests*, Monograph 8, Part 1, 1913.

high—of chalky limestone, and the tributary streams have all the characteristics of youth.

The sides of the Black Belt trough are bounded on the north and south by ridges, formed of the more resistant strata of the Coastal Plain, which rise 200 to 300 feet above the general level of the surface. The pronounced cuesta which forms the southern border of the trough is composed of the sandy, more resistant Ripley (Cretaceous) sediments.

The Black Belt, Black Prairie, Cotton Belt, or Cane Brake, as it has been variously called, can be briefly described as a belt of rich, black soil with an average width of 20 to 25 miles, and an area in Alabama of about 4,300 square miles. It extends in an east-west direction in south central Alabama and conforms exactly with an easily decomposed, impure, chalky limestone of rather uniform composition (Selma chalk) which has a thickness of about 1,000 feet in the western part of the state and thins out and disappears in the east near Montgomery. This formation dips to the south at the rate of 30 to 40 feet to the mile while the surface slopes at a much less rapid rate in the same direction. It is the weathering of the beveled edges of this limestone that determines the width and position of the Black Belt. The soil formed from this rock is a clay of exceptional fertility but somewhat difficult to cultivate because it bakes in summer and becomes tenacious mud in winter.

After the deposition of the Coastal Plain sediments a deposit of red sandy loam, called the Lafayette formation, was laid down on them, either during the early Pleistocene or near the close of the Pliocene, and formed a veritable mantle covering many hundreds of square miles. The depth of this formation is, in places, as much as fifty feet, but little of it has a thickness of more than 25 feet. The origin of the Lafayette has given rise to much discussion,¹ but as the underlying formations in Alabama contain little quartz from which pebbles could be made, the abundant water-worn quartz pebbles show that in this state, at least, it must have been transported long distances. On the sides of the Black Belt trough some knobs and ridges are capped by this deposit, proving

that the Black Belt was once covered with it. The almost complete absence of the Lafayette over the area underlain by the Selma chalk and its presence on other parts of the Coastal Plain north and south is attributable to the greater ease with which the chalk is weathered and eroded. Because of its solubility and lack of strength, the streams that flow through the limestone quickly cut their beds to grade. In other parts of the Coastal Plain which are underlain by limestone, it is also found that very little remains of the once widespread cover of Lafayette.

The features which lead to the belief that the Black Belt of Alabama is in the youthful stage of a first cycle of erosion was based upon the facts (1) that its surface is so level in certain areas as to give it an appearance of topographic youth; (2) that the rivers are bordered by steep banks or bluffs and are in a youthful stage of an erosion cycle.

The evidences which indicate that the region was peneplained and has been elevated in comparatively recent times are: (1) that it occupies a troughlike depression 200 to 300 feet lower than the bordering lands to the north and south; (2) that, although the soil is a clay, and is consequently very favorable for the retention of water, swamps are nevertheless uncommon except in river bottoms, showing that the drainage had been thoroughly established; (3) that the Lafayette, which once covered the Black Belt, has been almost entirely removed from it; (4) that the thick, residual soils of the region were probably formed chiefly after the land was reduced to a peneplain (at the present time they are being rapidly eroded away); (5) that the present youthful appearance of the region is due to a comparatively recent elevation of the peneplain 60 or more feet, which permitted the rivers to sink their beds; (6) that the peneplanation must have taken place during the Pleistocene, as is shown by the fact that the region was reduced to a nearly level surface and that a thick residual soil was formed after the removal of the Lafayette, a formation that was deposited not earlier than late Pliocene and, more probably, during the Pleistocene.

Estimates of the length of geological time are so uncertain that little dependence can be placed on them, but it is, nevertheless,

interesting to speculate upon the time required for the removal of the Lafayette loams, sands, and gravels from the Black Belt and for the reduction of the surface during part of the Pleistocene. Penck's estimate of 500,000 to 1,000,000 years for the duration of the Pleistocene, based upon the rate of advance and retreat of the Pleistocene Ice Sheets, is to be contrasted with Barrell's¹ minimum estimate of 1,500,000 years based upon a study of radioactivity. A few years ago Barrell's estimate would have seemed extravagant, but when one considers that a region, such as the one under discussion, has been denuded of a thick deposit of gravel and loam, has been reduced to a peneplain, has been weathered so long as to form a thick residual soil, has been raised, and, finally, has been so dissected by streams as to make a topography of youthful aspect, the larger estimate does not seem impossible.

In 1906, Chamberlin and Salisbury² presented figures as to the duration of time since the Kansan glacial epoch, giving 300,000 as a likely minimum, and 1,020,000 as a likely maximum. Had the statement covered the time since the beginning of the Pleistocene, these figures would have been considerably larger.

The physiographic history of the Coastal Plain of the Gulf of Mexico has not as yet been carefully worked out, and it is probable that a thorough study will show that this surface instead of being the youthful topography of a first cycle of erosion, is, for the most part, the incised surface of a peneplain or a plain of marine abrasion, in which are subordinate peneplains such as that of the Black Belt. The unconsolidated sediments and broad intervalles give the impression of youth but the beveled edges of the formations which underlie the Coastal Plain and the level, outstanding cuesta ridges are suggestive of peneplanation. The writer hopes to be able to make a further study of the physiographic history of our Gulf Coastal Plain and with it a study of the Atlantic Coastal Plain.

¹ J. Barrell, "Measurements of Geological Time," *Geological Society of America Bulletin*, Vol. XXVIII (1917), p. 892.

² *Earth History*, Vol. III, p. 420.



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